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THERMOCHEMISTRY
OF THE
CHEMICAL SUBSTANCES

THE ASSEMBLY OF A SELF CONSISTENT TABLE OF "BEST"
VALUES FOR THE HEATS OF FORMATION OF THE CHEMICAL
SUBSTANCES (EXCEPT CARBON COMPOUNDS CONTAINING
MORE THAN TWO CARBON ATOMS), INCLUDING HEATS OF
TRANSITION, FUSION, AND VAPORIZATION

By

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PREFACE

The assembly of the table of values for the heats of formation in the section on Thermochemistry in the International Critical Tables was the first attempt ever made to collate all the published data involving heats of reaction and to prepare therefrom a self-consistent table of "best" values for the heats of formation of the chemical substances. The present book is a complete revision and extension of that original work, which was sponsored by the late Edward W. Washburn as Editor-in-Chief of the International Critical Tables and carried out by one of the present authors (F. R. B.)

The assembly of a self-consistent table of values for the heats of formation of all the chemical substances requires (1) that all the original experimental data be recalculated with the use of appropriate auxiliary data, (2) that the value selected for the heat of formation of a given substance be as accurate as it is possible to obtain from the known data, and (3) that the selected "best" value be as consistent as possible with all the other values in the table and with all the known thermochemical data on reactions involving that substance.

There are four main sections to the present book: (1), the introduction or explanatory part; (2), the table of heats of formation, which is the fruit of the work; (3), the text, in which the original published data are cited and discussed; and (4), the list of references to the literature, which includes references to all the published data bearing on thermochemistry.

The introduction gives all the necessary information concerning the units, symbols, abbreviations, method of utilizing the table, etc.

The table of values contains a list of all the chemical substances (except carbon compounds containing more than 2 carbon atoms), for which there are thermochemical data, together with values for the heats of formation (or heat of transition, fusion, or vaporization) of each substance. It was deemed expedient not to include in the present table values for the heats of formation of carbon compounds containing more than two carbon atoms. It should be possible to obtain from this table, by simple addition and subtraction, the heat of any process involving any of the substances given, with an accuracy as great as is actually known. There are listed in the table 5840 values of heats of formation, and, in addition, 350 values of heats of transition, fusion, vaporization, or reaction, for substances for which no values are given for the heat of formation.

In the text, each paragraph or group of paragraphs is labeled with the formula of a chemical substance (or substances), and under that heading are cited all the published thermochemical data on reactions which can

be utilized to compute the heat of formation of the given substance (or substances).

In the list of references are given the citations to the literature for all the published works bearing on thermochemistry which are discussed or mentioned in the text. This list of 3730 references includes all the publications covered by Chemical Abstracts up to January 1, 1931, and nearly all of the important and significant contributions which have been published in the period from January 1, 1931, to January 1, 1934.

The symbols given in this book for the various heats of reaction, fusion, vaporization, sublimation, transition, dissociation, and formation are merely abbreviations used for convenience in the present work, and are not proposed to be used in lieu of, or in connection with, the regularly accepted symbols of chemical thermodynamics.

The standard temperature selected for the values given in this book is 18° Centigrade, following the procedure of the thermochemistry section (Bichowsky¹) of the International Critical Tables. The authors have been reluctant not to use the almost universally accepted standard temperature of 25° Centigrade for thermodynamic calculations; but the selection of 18° as the standard temperature is practically necessary in this case because all of the monumental work of Julius Thomsen and of Marcellin Berthelot was done at or near 18° and there are not now available sufficient heat capacity data with which to make accurate conversion to 25° (this is especially important for reactions involving substances in aqueous solution where the temperature coefficient is usually very large). In later years, as the data on heat capacities become available, or as the heats of many of the reactions, which have until the present time been measured only by Thomsen or Berthelot or both, are redetermined, it will be quite feasible to use 25° as the standard temperature.

Where it is expedient and necessary, each unusual method of calculation used in the text is explained. The ordinary and simple methods of calculating thermochemical values are assumed to be known to the reader, and the advanced methods which are used but not described may be found explained in one of the many current books on advanced physical chemistry or thermodynamics.

The authors will greatly appreciate the cooperation of readers in making known the errors which they find in this book. Grateful acknowledgment is made to Anne Landgraff Rossini for aid in compilation and checking the copy and proofs.

In compiling the present book, the authors hope that their work will materially aid all those who have need of the data of thermochemistry, and will feel amply rewarded if their efforts help to stimulate renewed activity in the much-neglected but vastly important field of thermochemical research.

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FREDERICK D. ROSSINI

Washington, D. C.

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INTRODUCTION

Scale of temperature. With a few exceptions all temperatures recorded in this book are on the Centigrade scale, and, for convenience, temperatures on the Centigrade scale are indicated by a numeral and degree mark without the letter "C," as 18°.

Unit of energy. The fundamental unit of energy in modern thermochemical measurements is the electrical joule, which is derived from standards of resistance and electromotive force maintained at the various national standardizing laboratories.

In the section on Thermochemistry in the International Critical Tables (see Bichowsky¹), the values were recorded in joules, in the hope that thermochemists might come to use this fundamental unit in their calculations and writings. But the attempt to break away from the calorie as a unit in thermochemical and thermodynamical calculations proved to be unpopular and apparently hopeless of accomplishment. In order to satisfy the popular demand for the calorie as a unit in calculations and tabulations, and at the same time depart as little as possible from the fundamental unit of energy, the joule, in terms of which all accurate thermochemical measurements are actually made, we have used in this book a **defined calorie**, that is, one which has no actual relation whatever, except incidentally and historically, to the heat capacity of water.

In our calculations, the modern experimental data, which have been fundamentally obtained in terms of the international joule, have been converted to a **defined calorie** by means of the following relations (see Rossini^{2, 13}): 1 calorie=4.1850 absolute joules; 1 international joule =1.0004 absolute joules; 1 calorie=4.1833 international joules. The values from the older experimental data have been converted to this unit by means of the appropriate factors.

For conversion of values expressed in terms of the **defined calorie** to other desired units, the following factors can be used:

To convert the value in kilocalories to its equivalent in	Multiply the value in kilocalories by
International kilojoules	4.1833
Absolute kilojoules	4.1850
Absolute volt-electrons	0.04337

For converting data on the electromotive force of cells, the value of the Faraday constant has been taken as equal to 23.066 kilocalories per international volt-equivalent.

All the energy values, unlabeled with regard to units, that are given in the text and table are in terms of the kilocalorie defined in the foregoing manner.

Unit amount of substance. The unit amount of each chemical substance is taken to be that mass represented by its gram formula weight. In recomputing the data of those investigators who reported their results in terms of "weights in air," the authors have reduced to *vacuo* all pertinent weights, when such reduction was significant. *All values of energy given in this book are understood to be for one mole of the given substance (or reaction).* The atomic weights given in the table are those from the 1934 Report of the Committee on Atomic Weights of the International Union of Chemistry (see Baxter, Curie, Hönigschmid, Le Beau, and Meyer¹). Where the necessary changes were at all significant, the thermochemical values given in the text and table have been changed to conform to the foregoing table of atomic weights.

However, it should be pointed out that great caution must be exercised in attempting any such conversion because of the many different methods which have been used to determine the amount of a given calorimetric reaction. For example, to determine the amount of the reaction, $\text{Na(c)} + \text{H}_2\text{O(lq.)} = \text{NaOH(aq.)} + \frac{1}{2} \text{H}_2(\text{g})$, one can (1) determine the mass of Na used, (2) determine the mass of H_2 produced, or (3) determine the amount of NaOH by titration with (for example) an aqueous solution of HCl which has been standardized with AgNO_3 which in turn has been prepared from a weighed amount of pure Ag. The calculation of the number of moles of reaction taking place will depend in case (1) on the atomic weight of Na, in case (2) on that of H, and in case (3) on that of Ag. Another example is that the value obtained by Rossini^{4,8} for the heat of combustion of 1 mole of CH_4 is independent of the atomic weight of carbon, because the amount of calorimetric reaction was determined from the mass of H_2O formed in the combustion.

Standard states. The standard or reference state of each of the elemental substances is taken to be that physical state (or one of them, if there are two or more) in which the element naturally exists at a pressure, or a fugacity, of one atmosphere and at a temperature of 18°. The isotopic composition of each element in its standard state is understood to be the naturally existing one. For the element carbon, we have selected its form as diamond, C (c, diamond), as the standard state because no other form of solid carbon is at present a reproducible and invariable one.

Aqueous Ions. In order to facilitate the computation of the heats of formation of aqueous strong electrolytes, we have taken as an arbitrary reference point for aqueous ions the heat of formation of aqueous hydrogen ion, $\text{H}^+(\text{aq.})$, to be zero. Therefore, the values given in the table for the heats of formation of individual aqueous ions are not the actual

heats evolved in the reaction of forming those individual ions from their elements in the standard states, but the sum of the values for a number of ions whose charges sum to zero does represent the actual heat of formation of the sum of those aqueous ions.

Conventions as to temperature, pressure, and concentration. *Every heat of formation or heat of reaction value given in the table or in the text is understood to be, unless otherwise specified, the value for the heat evolved when the reaction takes place at a constant pressure, or a fugacity, of one atmosphere and at a temperature of 18°. This means that those data obtained at some other temperature have been converted, when the conversion is at all significant, to a temperature of 18°; and that those data obtained at other than constant pressure have been converted to constant pressure. For substances in aqueous (or other) solution, the concentration, when known, is indicated. When the concentration is not indicated, it is understood to be for a "dilute" solution.*

Physical state and its description. The physical state of each substance is indicated, in the text and in column 2 of the table, as gaseous, liquid, crystal, glass, colloidal, or in aqueous or other solution. (See the list of abbreviations on page 14.) All states are for a pressure, or a fugacity, of one atmosphere and a temperature of 18°, unless otherwise indicated.

Numerals, in column 2 of the table or in the text in parentheses following the formula of the substance, indicate that one mole of the substance is dissolved in that number of moles of H_2O . When the concentration is not known, there is written, instead of the numeral, the abbreviation "aq." which indicates a large number of moles of H_2O , i. e., the solution is "dilute."

When the substance is dissolved in a solvent other than water, the formula (or name) of the solvent is given, and, if known, the number of moles of it per mole of solute. When the concentration is not given, the solution is understood to be "dilute."

In column 3 of the table are recorded items which serve to identify the substance for which the value of the heat of formation is given. For crystalline substances having stable transition points, the various solid crystalline forms are indicated as I, II, III, IV, etc., beginning with the form stable at the normal melting point. For atoms, ions, and certain molecules, in the gaseous state, the electron configuration and term symbols are given (see Mulliken,⁶ Jevons,¹ and Bacher and Goudsmit¹).

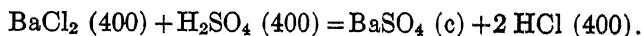
Heat of formation. The heat of formation of a substance, as MX (crystal), is taken to mean the heat evolved in the reaction of forming one mole (gram formula weight) of that substance from its elements in their standard states (as, for example: $\text{M (liq.)} + \frac{1}{2} \text{X}_2 \text{ (g)} = \text{MX (c)}$) at a constant pressure (or a fugacity) of one atmosphere and, unless otherwise

specified, at a temperature of 18°. The values for the heats of formation of the substances are given in the table in the column headed Q_f . In the text these values are also labeled Q_f . Translated into the nomenclature of Lewis and Randall,⁵ $Q_f = -\Delta H^\circ$ (formation), the decrement in heat content accompanying the reaction of forming the given substance from its elements in their standard states.

In this book, the values for the heats of formation of substances in aqueous or other solution represent values of the apparent molal heat content, not the partial molal heat content (see Lewis and Randall⁵ and Rossini⁶). That is to say, for example, the value of Q_f for NaCl (200) means actually the heat of the reaction, $\text{Na (c)} + \frac{1}{2} \text{Cl}_2 \text{ (g)} + 200 \text{ H}_2\text{O (liq.)} = (\text{NaCl} \cdot 200 \text{ H}_2\text{O}) \text{ (liq.)}$, though it is written here for convenience as $\text{Na (c)} + \frac{1}{2} \text{Cl}_2 \text{ (g)} = \text{NaCl (200)}$. And, similarly, the difference between the values of Q_f for NaCl (200) and NaCl (400) gives the heat of the reaction, $(\text{NaCl} \cdot 200 \text{ H}_2\text{O}) \text{ (liq.)} + 200 \text{ H}_2\text{O (liq.)} = (\text{NaCl} \cdot 400 \text{ H}_2\text{O}) \text{ (liq.)}$, which equation is written, by the convention of this book, as $\text{NaCl (200)} = \text{NaCl (400)}$.

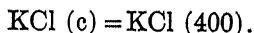
Computation of the heat of any process. To compute the heat of any process involving the disappearance of a substance or substances in the states given in the table and the appearance of other or the same substances in states given in the table: Add together the heat of formation (values for Q_f) of the products of the process in the final states and subtract therefrom the sum of the heats of formation (values for Q_f) of the reactants in their initial states. The value so obtained represents the heat evolved when the given process takes place at a constant pressure (or a fugacity) of one atmosphere and at a temperature of 18°. The following are examples:

Heat of reaction



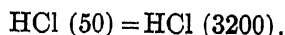
$$\begin{aligned} Q &= -\Delta H = \{ Q_f [\text{BaSO}_4 \text{ (c)}] + 2 Q_f [\text{HCl (400)}] \} - \\ &\quad \{ Q_f [\text{BaCl}_2 \text{ (400)}] + Q_f [\text{H}_2\text{SO}_4 \text{ (400)}] \}. \\ &= \{ 349.4 + 2 (39.525) \} - \{ 207.350 + 211.84 \} = 9.260. \end{aligned}$$

Heat of solution



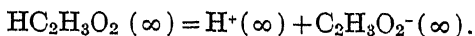
$$Q = -\Delta H = Q_f [\text{KCl (400)}] - Q_f [\text{KCl (c)}] = 99.899 - 104.361 = -4.462.$$

Heat of dilution



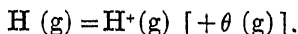
$$Q = -\Delta H = Q_f [\text{HCl (3200)}] - Q_f [\text{HCl (50)}] = 39.629 - 39.257 = 0.372.$$

Heat of ionization in aqueous solution



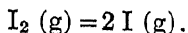
$$Q = -\Delta H = \{Q_f [\text{H}^+(\infty)] + Q_f [\text{C}_2\text{H}_3\text{O}_2^-(\infty)]\} - Q_f [\text{HC}_2\text{H}_3\text{O}_2 (\infty)] \\ = \{0.000 + 117.946\} - 118.070 = -0.124.$$

Heat of ionization in the gaseous phase



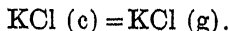
$$Q = -\Delta H = Q_f [\text{H}^+(\text{g})] - Q_f [\text{H} (\text{g})] = -365.58 - (-51.90) = -313.68.$$

Heat of dissociation



$$Q = -\Delta H = 2Q_f [\text{I} (\text{g})] - Q_f [\text{I}_2 (\text{g})] = 2 (-25.59) - (-14.91) = -36.27.$$

Heat of sublimation



$$Q = -\Delta H = Q_f [\text{KCl} (\text{g})] - Q_f [\text{KCl} (\text{c})] = 52.4 - 104.361 = -52.0.$$

Accuracy of the values. All the values recorded in the table have been recomputed from the original experimental data, using consistent values for all subsidiary quantities. Heats of reaction, of dilution, of solution, of neutralization, of transition, etc., may be computed by difference with an accuracy as high as is known. The number of significant figures in any one value in the table does not indicate the absolute accuracy of that value, which will be less than that of the least accurate determination in the total chain of reactions used to calculate the value. In most cases, sufficient information to deduce the accuracy of any value is given in the text.

References to the literature. References to the original data are given in the text, as Washburn.² The exact citation can then be found in the list of references, which are given in alphabetical (and numerical) order, as Washburn,² *Bur. Standards J. Research* 10, 525 (1933), where the numerals indicate, respectively, the volume, page, and year. The abbreviations used for the titles of the periodicals are those adopted as standard by the International Union of Chemistry (See, for example, Chemical Abstracts' "List of Periodicals Abstracted"). When the citation is that of a book, it is written as Washburn, "Introduction to the Principles of Physical Chemistry," McGraw-Hill Book Co., New York (1921), where the title is in quotation marks, and then in order follow the name of the publisher, the place of publication, and, in parentheses, the year of publication. If the book citation includes volume and page numbers, these follow immediately after the title.

Superscripts and subscripts. A numeral superscript, as E^{25} , indicates the temperature in degrees Centigrade. For convenience, the super-

script “*z*” (as, for example, D^z) is used in place of the superscript “-273” to indicate the absolute zero of temperature.

The asterisk superscript “*” applied to the formula of a given chemical substance indicates that the given ion, atom, or molecule is in an excited state, that is, in an electronic state having an energy content greater than that of the ground or normal state.

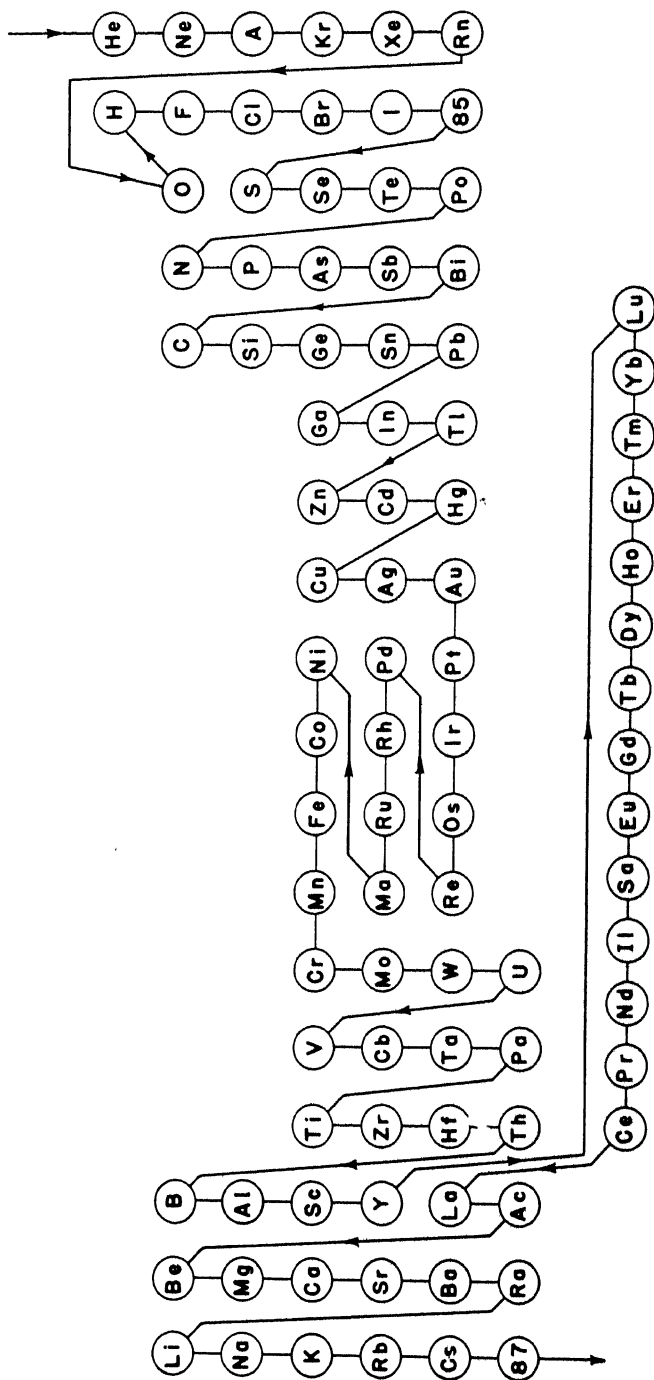
A numeral subscript, as A_{100} , indicates the number of moles of H_2O per mole of solute in the solution. A word subscript, as A_{CH_3OH} , with or without a numeral subscript giving the number of moles of solvent, indicates the solvent, if other than H_2O . These subscripts and superscripts may be attached either to the symbol representing the kind of reaction or to the number representing the value of the heat of the reaction.

Abbreviations. The following abbreviations are used:

amorp.	Amorphous, or ill defined solid state.
aq.	In a dilute aqueous solution.
c	Macrocrystalline.
<i>C</i>	Heat of combustion. The heat evolved in the combustion of the given substance at constant pressure in oxygen.
<i>D</i>	Heat of dissociation. When applied to gaseous diatomic molecules, <i>D</i> represents the heat evolved in the reaction, $Z_2(g) = 2Z(g)$, at constant pressure (or fugacity). When applied to hydrates, ammines, etc., <i>D</i> represents the heat evolved, per mole of gaseous H_2O (or of NH_3 , etc.) in the reaction, $Z \cdot n H_2O(c) = Z \cdot (n-a) H_2O(c) + a H_2O(g)$, at constant pressure.
<i>E</i>	Excitation energy. The energy evolved in the process of elevating a gaseous substance from a given electronic energy state to a higher electronic energy state.
<i>F</i>	Heat of fusion. The heat evolved in the reaction, $Z(c) = Z(liq.)$, at constant pressure.
<i>g</i>	Gas.
gls.	A glass or solid supercooled liquid.
<i>I</i>	Energy of ionization of a gaseous substance. The energy evolved in the process of removing an electron from a gaseous substance.
(ideal)	In the condition indicated by the formula, e. g., for $N_2O_4(g)$, the word “(ideal)” indicates that the heat of formation is for a gas composed only of N_2O_4 molecules.
liq.	Liquid.

<i>N</i>	Heat of neutralization. The heat evolved in the reaction, $HX(aq.) + MOH(aq.) = MX(aq.) + H_2O(liq.)$, at constant pressure.
ppt.	Precipitated.
<i>Q</i>	Heat of reaction. The heat evolved when the given reaction takes place at constant pressure. In the nomenclature of Lewis and Randall, ⁵ $Q = -\Delta H$.
<i>Qf</i>	Heat of formation. The heat evolved in the reaction of forming the given substance from its elements in their standard states, at constant pressure. In the nomenclature of Lewis and Randall, ⁵ $Qf = -\Delta H^\circ$ (formation).
<i>S</i>	Heat of solution (in water unless specified otherwise by a word subscript). The heat evolved in the reaction, $Z(c, liq., \text{ or } g) = Z(aq.)$ (or other solvent), at constant pressure.
satd.	In a saturated solution in water.
$T^{110} \rightarrow II$	Heat of transition. For example, when given in connection with the substance $Z(c, I)$, $T^{110} \rightarrow II$ is the heat evolved in the reaction, $Z(c, I) = Z(c, II)$, at constant pressure and at 110° .
<i>X</i>	F, Cl, Br, or I.
<i>V</i>	Heat of vaporization. The heat evolved in the reaction, $Z(liq.) = Z(g)$, at constant pressure.
<i>Vs</i>	Heat of sublimation. The heat evolved in the reaction, $Z(c) = Z(g)$, at constant pressure.
θ	Electron gas.

Order of arrangement of the chemical substances in the table. The substances listed in the thermochemical table are arranged in a manner analogous to that used in the International Critical Tables. The principle of this method is as follows: The chemical elements are arranged in a certain prescribed order, as *a, b, c, d, e, f, g, h*, etc. Then all the chemical substances will be arranged in the table in the following order: *a; b, ba; c, ca, cb, cba; d, da, db, dba, dc, dca, dc, dcba*; etc. In this book, the prescribed order of the elements is that given in the diagram on page 16. With several exceptions, the arrangement follows the periodic table quite closely, starting with the rare elements, going through the negative elements, and ending with the most positive substance, element 87.



Order of arrangement of the chemical elements.

Helium

Atomic number 2

Standard state He (g)

Atomic weight 4.002

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
He	g	1s ² (¹ S ₀)	0.000	
	liq.			V — 0.022 ⁻²⁷⁰
He *	c			F — 0.03 ⁻²⁶⁸
	g	2s (³ S ₁)	— 456.46	I^* — 109.47
He ⁺	g	(¹ S ₀)	— 474.74	I^* — 91.19
	g	1s (² S _{1/2})	— 565.93	I^* — 564.475
He ⁺⁺	g		— 1826.59	I^* — 1249.21
He ₂ *	g	³ Σ ⁺ _u	— 404.16	D^* — 51.4
	g	¹ Σ ⁺ _u	— 411.1	
He ₂ ⁺	g	² Σ ⁺ _u	— 503.4	

Neon

Atomic number 10

Standard state Ne (g)

Atomic weight 20.183

Ne	g	2p ⁶ (¹ S ₀)	0.000	
	liq.			V — 0.44 ⁻²⁴⁶
Ne *	c			F — 0.078 ⁻²⁴⁹
	g	2p ⁵ (² P _{1/2})3s (³ P ₀)	— 383.77	E^* — 383.77
Ne *	g	(⁴ P ₀)	— 380.41	E^* — 380.41
	g	2p ⁵ (² P _{3/2})3s (¹ P ₁)	— 381.56	E^* — 381.56
	g	(² P ₁)	— 382.75	E^* — 382.75
	g	(² P _{3/2})	— 382.75	E^* — 382.75
Ne ⁺	g	2p ⁵ ² P _{3/2}	— 496.56	I^* — 495.11
Ne ⁺ *	g	² P _{1/2}	— 498.79	E^* — 2.23
	g	2p ⁶ ² S _{1/2}	— 1014.47	E^* — 617.91
Ne ⁺⁺	g	2p ⁴ ³ P ₂	— 1438.67	I^* — 940.66
Ne ⁺⁺⁺	g	2p ³ ⁴ S _{3/2}	— 2896.8	I^* — 1456.7

Argon

Atomic number 18

Standard state A (g)

Atomic weight 39.944

A	g	3p ⁶ ¹ S ₀	0.000	
	liq.			V — 1.50 ⁻¹⁸⁶
A-5H ₂ O	c			F — 0.265 ⁻¹⁸⁹
	g		356.7	D — 14.8 ⁴ —H ₂ O (liq.)
A *	g	3p ⁵ (² P _{3/2})4s (¹ P ₁)	— 265.14	E^* — 265.141
	g	(² P ₁)	— 266.87	E^* — 266.867
	g	3p ⁵ (² P _{1/2})4s (³ P ₀)	— 269.15	E^* — 269.153
	g	(⁴ P ₁)	— 271.56	E^* — 271.562
A ⁺	g	3p ⁵ (² P _{3/2})	— 362.29	I^* — 361.839
A ⁺ *	g	² P _{1/2}	— 366.36	E^* — 4.07
	g	3p ⁶ ² S _{1/2}	— 671.82	E^* — 309.532
A ⁺⁺	g	3p ⁴ ³ P ₂	— 999.61	I^* — 635.87
A ⁺⁺ *	g	³ P ₁	— 1002.76	E^* — 3.16
	g	³ P ₀	— 1004.09	E^* — 4.48
A ⁺⁺⁺	g	3p ³ ⁴ S _{3/2}	— 1939.0	I^* — 937.95
A ⁺⁺⁺⁺	g	3p ²	— 5860.	I^* — 3920.

Krypton

Atomic number 36

Standard state Kr (g)

Atomic weight 83.7

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Kr	g	4p ⁶ ¹ S ₀	0.000	V — 2.31 ⁻¹⁸¹
	liq.			F — 0.36 ⁻¹⁸⁷
Kr·5H ₂ O	c	4p ⁶ (² P _{3/2})5s (1 ¹ ₂)	356.6	D — 14.7 [±] - H ₂ O (liq.)
	c			E* — 227.662
Kr*	g	(2 ¹ ₁)	— 227.66	E* — 230.360
	g	4p ⁶ (² P _{1/2})5s (3 ¹ ₀)	— 242.52	E* — 242.521
	g	(4 ¹ ₁)	— 244.39	E* — 244.386
	g	4p ⁶ ² P _{3/2}	— 322.90	I* — 321.445
Kr ⁺	g	(² P _{1/2})	— 338.18	E* — 15.29
Kr ⁺⁺	g	4p ⁴ ³ P ₂	— 943.	I* — 619.
Kr ⁺⁺⁺	g	4p ³ (⁴ S _{3/2})	— 1664.6	I* — 720.15

Xenon

Atomic number 54

Standard state Xe (g)

Atomic weight 131.3

Xe	g	5p ⁶ ¹ S ₀	0.000	V — 3.27 ⁻¹⁰⁹
	liq.			F — 0.49 ⁻¹⁴⁰
Xe·6H ₂ O	c	5p ⁶ (² P _{3/2})6s (1 ¹ ₂)	428.	D — 18.1 [±] - H ₂ O (liq.)
	c			E* — 139.688
Xe*	g	(2 ¹ ₁)	— 139.69	E* — 142.353
	g	5p ⁶ (² P _{1/2})6s (3 ¹ ₀)	— 142.35	E* — 165.677
	g	(4 ¹ ₁)	— 165.68	E* — 168.490
	g	5p ⁶ ² P _{3/2}	— 168.49	E* — 168.490
Xe ⁺	g	(² P _{3/2})	— 228.73	I* — 227.27
	g	² P _{1/2}	— 231.73	E* — 3.00
	g	5p ⁶ ² S _{1/2}	— 487.42	E* — 258.69
Xe ⁺⁺	g	5p ⁴ ³ P ₂	— 717.17	I* — 486.99
Xe ⁺⁺⁺	g	5p ³ (⁴ S _{3/2})	— 1376.0	I* — 657.5

Radon

Atomic number 86

Standard state Rn (g)

Atomic weight 222.

Rn	g	¹ S ₀	0.000	V — 43 ⁻⁶²
	liq.			F — 0.8 ⁻⁷¹
Rn*	c	6p ⁶ (² P _{3/2})7s (1 ¹ ₂)	— 155.49	E* — 155.49
	c			E* — 159.39
	g	(2 ¹ ₁)	— 159.39	E* — 193.32
	g	6p ⁶ (² P _{1/2})7s (3 ¹ ₀)	— 193.32	E* — 196.12
Rn ⁺	g	(4 ¹ ₁)	— 196.12	I* — 246.79
	g	6p ⁶ (² P _{3/2})	— 248.24	

Oxygen

Atomic number 8

Standard state O₂ (g)[†]

Atomic weight 16.0000

Formula	State	Description	<i>Qf</i> , kcal. mole ⁻¹	<i>Q</i> , kcal. mole ⁻¹
O	g	2s ² 2p ⁴ (³ P ₂)	— 59.10	<i>D</i> [°] _{O₂} — 117.4
O*	g	(³ P ₁)	— 59.55	<i>E</i> [°] — 0.45
	g	(³ P ₀)	— 59.74	<i>E</i> [°] — 0.64
	g	(D ₂)	— 104.28	<i>E</i> [°] — 45.18
	g	(¹ S ₀)	— 155.30	<i>E</i> [°] — 96.20
O ⁺	g	2s ² 2p ³ (⁴ S ¹ _{3/2})	— 373.22	<i>I</i> [°] — 312.67
O ⁺ *	g	(² D ¹ _{5/2})	— 449.56	<i>E</i> [°] — 76.34
	g	(² D ¹ _{3/2})	— 449.62	<i>E</i> [°] — 76.40
	g	(² P ¹ _{3/2})	— 488.42	<i>E</i> [°] — 115.20
	g	(² P ¹ _{1/2})	— 488.44	<i>E</i> [°] — 115.22
O ⁺⁺	g	2s ² 2p ² (³ P ₀)	— 1180.39	
O ⁺⁺ *	g	(³ P ₁)	— 1180.72	<i>E</i> [°] — 0.33
	g	(³ P ₂)	— 1181.27	<i>E</i> [°] — 0.88
O ⁺⁺⁺	g	2s ² 2p (² P ¹ _{1/2})	— 2447.3	<i>I</i> [°] — 1265.
O ⁺⁺⁺ *	g	(² P ¹ _{3/2})	— 2448.4	<i>E</i> [°] — 1.10
O ⁺⁺⁺⁺	g	2s ² (¹ S ₀)	— 4224.	<i>I</i> [°] — 1775.5
O ⁺⁺⁺⁺⁺	g	2s (² S ¹ _{1/2})	— 6742.	<i>I</i> [°] — 2517.8
O ⁺⁺⁺⁺⁺⁺	g	1s ² (¹ S ₀)	— 9914.	<i>I</i> [°] — 3170.2
O ⁺⁺⁺⁺⁺⁺	g	1s (² S ¹ _{1/2})	— 26817.	<i>I</i> [°] — 16900.
O ⁺⁺⁺⁺⁺⁺	g		— 46810.	<i>I</i> [°] — 19992.
O ⁻	g		— 30.	
O ⁻	g		— 225.	
O ₂	g	(³ Σ ⁻ _g)	0.000	
	liq.			<i>V</i> — 1.629 ^{-189.0}
	c	I		<i>F</i> — 0.106 ^{-218.7}
	c	II		<i>T</i> — 0.178 ^{-220.4} → I
	c	III		<i>T</i> — 0.023 ⁻²⁵⁰ → II
	aq.		3.85	<i>S</i> — 3.85
O ₂ *	g	(¹ Σ ⁺ _g)	— 37.36	<i>E</i> [°] — 37.36
O ₂ ⁺	g		— 280.	<i>D</i> [°] — 149.6
O ₂	g		— 34.5	
	liq.			<i>V</i> — 2.96 ^{-112.8}
	aq.		— 32.7	<i>S</i> — 1.8
O ₄	g		0.13	

[†]Natural mixture of isotopes.

Hydrogen				
Atomic number 1	Standard state	H ₂ (g) [†]	Atomic weight 1.0078	
Formula	State	Description	Qf, kcal. mole ⁻¹	Q, kcal. mole ⁻¹
H	g	1s (³ S _{1/2})	— 51.90	D [°] H ₂ — 102.9
H ⁺	g		— 365.58	I [°] — 312.23
	aq.	(by convention)	0.000	
H ⁻	g		— 34.85	
H ₂	g	equilibrium [†]	0.000	
	liq.			V — 0.216 ⁻²⁸⁵
	c			F — 0.0282 ⁻²⁴³
	aq.		1.42	S 1.42
	solid	adsorbed on Pt	13.8	
H ₂ ⁺	g	B (¹ Σ ⁺ _u)	— 256.8	E [°] — 256.8
	g	C (¹ Π _u)	— 282.2	E [°] — 282.2
H ₂ ⁺	g	(² Σ ⁺ _g)	— 357.52	* I [°] — 356.07
OH	g	² Π	5.93	
OH ⁺	g	² Σ ⁺	— 86.33	
OH ⁻	g		— 58.	
	∞		54.660	N 13.710 _∞
H ₂ O	g		57.801	V — 10.571
	liq.		68.370	
	c			F — 1.437 ⁰
H ₂ O ₂	g		33.59	V — 11.61
	liq.		45.20	S 0.46 ₂₀₀
	c			F — 2.52 ⁻³
	200		45.66	
	6.3		45.64	
	2.6		45.63	
	1.0		45.4	

[†]Natural mixture of isotopes; molecules in equilibrium with respect to symmetric and antisymmetric rotational states.

Fluorine

Atomic number 9

Standard state $F_2(g)$

Atomic weight 19.00

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
F	g	$2p^5$ ($^2P_{1/2}$)	- 31.75	$D^{\circ}_{F_2}$ - 62.6
F*	g	($^2P_{1/2}$)	- 32.91	E° - 1.16
F ⁺	g	$2p^4 3s$ ($^4S_{1/2}$)	- 462.95	I° - 429.75
F ⁺ *	g	$2p^4 3p$ (4P_1)	- 503.64	E° - 73.89
	g	(4P_2)	- 503.67	E° - 73.92
	g	(4P_3)	- 503.73	E° - 73.98
F ⁺⁺	g	$2p^3$ ($^4S_{1/2}$)	- 1262.05	I° - 797.65
F ⁺⁺⁺	g	$2p^2$ (2P_0)	- 2601.30	I° - 1133.8
F ⁺⁺⁺ *	g	(2P_1)	- 2601.99	E° - 0.66
	g	(2P_2)	- 2602.48	E° - 1.18
F ⁺⁺⁺⁺	g	$2p$ ($^2P_{1/2}$)	- 4562.3	I° - 1959.6
F ⁺⁺⁺⁺⁺	g	$2s^2$ (1S_0)	- 7169.8	I° - 2606.
F ⁺⁺⁺⁺⁺⁺	g	$2s$ ($^2S_{1/2}$)	- 10697.	I° - 3526.
F ⁺⁺⁺⁺⁺⁺⁺	g	$1s^2$ (1S_0)	- 14941.	I° - 4243.
F ⁺⁺⁺⁺⁺⁺⁺ +	g	$1s$ ($^2S_{1/2}$)	- 17124.	I° - 2181.
F ⁻	g		66.3	
	∞		78.20	
F ₂	g		0.000	
	liq.			V - 1.60 ⁻¹⁸⁸
	c			F - 0.34 ⁻²²⁰
HF	g	ideal	64.0	S 11.56 ₂₀₀
	liq.		71.0	S 4.60 ₂₀₀
	c			F - 1.09 ⁻⁸³
	600		75.7	
	200		75.56	
	12		75.56	
	6		75.46	
	2.2		75.11	
	1.7		74.74	
	0.5		73.5	
HF ₂ ⁻	aq.		153.4	
(HF) ₂ ⁺	g	at 745 mm. pressure	229.	
H ₂ F ₂	g		424.	
F ₂ O	g		- 5.5	

Chlorine

Atomic number 17

Standard state Cl_2 (g)

Atomic weight 35.457

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Cl	g	$3s^2 3p^5$ ($^2P_{3/2}$)	- 28.90	D°_{Cl} - 56.9
Cl*	g	($^2P_{1/2}$)	- 31.41	E° - 2.506
Cl ⁺	g	$3s^2 3p^4$ (3P_2)	- 329.46	I° - 299.11
Cl ⁺ *	g	(3P_1)	- 331.44	E° - 1.98
	g	(3P_0)	- 332.29	E° - 2.83
Cl ⁺⁺	g	$3s^2 3p^3$ ($^4S_{3/2}$)	- 863.97	I° - 533.06
Cl ⁺⁺⁺	g	$3s^2 3p^2$ (3P_0)	-1782.91	I° - 916.49
Cl ⁺⁺⁺ *	g	(3P_1)	-1784.31	E° - 1.398
	g	(3P_0)	-1786.73	E° - 3.818
Cl ⁺⁺⁺⁺	g	$3s^2 3p$ ($^2P_{1/2}$)	-2888.	I° -1094.
Cl ⁺⁺⁺⁺ *	g	($^2P_{3/2}$)	-2892.	E° - 4.24
Cl ⁺⁺⁺⁺⁺	g	$3s^2$ (1S_0)	-4451.	I° -1563.
Cl ⁺⁺⁺⁺⁺⁺	g	$3s$ ($^2S_{1/2}$)	-6500.	I° -2047.
Cl ⁺⁺⁺⁺⁺⁺⁺	g	$2p^6$ (1S_0)	-9126.	I° -2625.
Cl ⁻	g		61.	
	∞		39.687	
Cl ₂	g		0.000	
	liq.			V - 4.4 ⁻³⁶
	c			F - 1.62 ^{-102.3}
	aq.	saturated	5.3	S 5.3
	aq.	ideal	7.0	
	CCl ₄		4.5	S 4.5 ^o CCl ₄
Cl ₂ ·6H ₂ O	c		428.2	
Cl ₂	g		- 25.	
ClO	g		- 31.	
ClO ⁻	aq.		25.9	
ClO ₂	g		- 23.5	S 6.6
	liq.		- 17.0	V - 6.52
	aq.		- 16.9	
ClO ₂ ⁻	∞		20.75	
ClO ₄ ⁻	∞		39.5	
Cl ₂ O	g		- 18.25	
	aq.		- 8.81	
	aq.	ideal	- 8.	
HCl	g		22.06	
	liq.			V - 3.86 ⁻³⁵
	c	I		F - 0.476 ⁻¹¹⁴
	c	II		T - 0.284 ^{-174.5} _{-I}
	∞		39.687	
	6400		39.647	
	3200		39.629	
	1600		39.606	
	800		39.572	
	400		39.525	

Chlorine

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HCl	200		39.465	
	100		39.382	
	50		39.257	
	25		39.032	
	20		38.92	
	18		38.86	
	15		38.73	
	12		38.55	
	10		38.35	
	8		38.06	
	6		37.52	
	5		37.10	
	4		36.44	
	3		35.43	
	2		33.56	
	1		28.3	
	CCl ₄		25.7	<i>S</i> 3.69° CCl ₄
	C ₂ H ₅ OH		32.6	<i>S</i> 10.6° C ₂ H ₅ OH
HCl ⁺	g		- 296.	<i>I</i> [*] - 318.
HCl·2H ₂ O	c			<i>F</i> - 2.5 ⁻¹⁸
HClO	400		29.78	
HClO ₂	aq.		13.8	
HClO ₃	aq.		20.8	
HClO ₄	660		39.6	
	200		39.6	
	96		39.63	
	42		39.59	
	10		39.54	
	6		39.24	
	4.15		39.00	
	3.08		38.37	
	2.33		35.24	
	1.43		32.23	
	1.0		27.9	
			25.7	
ClF	g			
	liq.			<i>V</i> - 2.27 ⁻¹⁰¹

Bromine

Atomic number 35

Standard state Br₂ (liq.)

Atomic weight 79.916

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Br	g	4s ² 4p ⁵ (² P _{3/2})	- 26.88	$D^{\circ}_{Br_2}$ - 45.24
Br*	g	(² P _{1/2})	- 37.37	E° - 10.49
Br ⁺	g	4p ³ 5s (⁴ S _{3/2})	- 298.92	I° - 270.59
Br ⁺ *	g	4p ³ 4d (⁶ D _{5/2})	- 299.37	E° - 0.447
	g	(⁶ D _{3/2})	- 299.45	E° - 0.529
	g	(⁶ D _{1/2})	- 299.53	E° - 0.612
	g	(⁶ D _{3/2})	- 299.64	E° - 0.717
	g	(⁶ D _{5/2})	- 299.75	E° - 0.831
Br ⁺⁺	g	4p ² 5s (⁴ P _{1/2})	- 741.	I° - 442.
Br ⁺⁺ *	g	(⁴ P _{3/2})	- 742.53	E° - 1.48
	g	(⁴ P _{5/2})	- 744.90	E° - 3.85
	g	4p ² 4d (⁴ P _{5/2})	- 753.90	E° - 12.85
	g	(⁴ P _{3/2})	- 755.22	E° - 14.17
	g	(⁴ P _{1/2})	- 755.81	E° - 14.76
Br ⁺⁺⁺	g	4p5s (¹ P ₁)	-1333.	I° - 592.
Br ⁻	g		61.6	I° - 87.9
	∞		28.67	
Br ₂	g		- 7.65	V - 7.65
	liq.		0.000	
	c			F - 2.53 ⁻⁷
	aq.	ideal	1.2	
	CCl ₄		- 0.5	S - 0.5 _{CCl₄}
	CHCl ₃		- 0.6	S - 0.6 _{CHCl₃}
	CS ₂		- 1.4	S - 1.4 _{CS₂}
Br ₂ ·10H ₂ O	c		700.	D - 7.9 ⁻¹⁰
Br ₃ ⁻	aq.		31.1	
Br ₅ ⁻	aq.		35.7	
BrO ⁻	aq.		21.3	
BrO ₃ ⁻	∞		11.2	
HBr	g		8.65	S 19.89 ₄₀₀
	liq.			V - 4.21 ^{-66.7}
	c	I		F - 0.575 ^{-66.9}
	c	II		T - 0.26 ⁻¹⁰⁰ _I
	c	III		T - 0.14 ⁻¹⁰⁰ _{II}
HBr	∞		28.67	
	3200		28.62	
	1600		28.60	
	800		28.58	
	400		28.55	
	200		28.52	
	100		28.47	
	50		28.39	
	25		28.23	

Bromine

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HBr	10		27.68	
	6		26.83	
	5		26.20	
	3		24.49	
	2		22.4	
	1		19.	
HBr·H ₂ O	c			F — 3.0 ⁻¹¹
HBr·2H ₂ O	c			D — 16.9 ⁰ →H ₂ O (liq.)
HBrO	aq.		25.2	
HBrO ₃	aq.		11.30	
BrCl	g		— 3.07	

Iodine

Atomic number 53

Standard state I₂ (c)

Atomic weight 126.92

I	g	5s ² 5p ⁵ (² P _{1/2})	— 25.59	$D^{\circ}_{1_2}$ — 35.40
I*	g	(² P _{1/2})	— 46.73	E° — 21.14
I ⁺	g	5p ³ 6s (⁴ S _{1/2})	— 267.54	I° — 240.5
I ₂	I ⁻		53.0	
	∞		13.37	
	g		— 14.91	V — 14.91
	liq.			F — 4.0 ^{113.5}
	c		0.000	
	aq.		— 5.0	
	C ₆ H ₆		— 6.0	S — 6.0 _{C₆H₆}
	C ₂ H ₅ OH		— 1.7	S — 1.7 _{C₂H₅OH}
	(C ₂ H ₅) ₂ O	in diethyl ether	— 1.6	S — 1.6 _{(C₂H₅)₂O}
	CCl ₄		— 5.8	S — 5.8 _{CCl₄}
I ₃ ⁻	CHCl ₃		— 6.0	S — 6.0 _{CHCl₃}
	CS ₂		— 5.0	S — 5.0 _{CS₂}
	aq.		12.14	
	aq.		20.	
	∞		54.5	
	aq.		37.6	
	aq.		146.4	
	c		42.5	S — 1.96 ₂₀₀
	g		— 5.91	S 19.19 ₂₀₀
	liq.		— 8.89	V — 4.72 ^{-36.4}
I ₂ O ₅	c	I		F — 0.686 ^{-50.8}
	c	II		T — 0.192 ^{-147.5} →I
	c	III		T — 0.019 ^{-208.0} →II
	c			
	∞		13.37	

Iodine

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HI	1600		13.31	
	800		13.30	
	400		13.29	
	200		13.28	
	100		13.26	
	50		13.22	
	25		13.11	
	20		13.07	
	10		12.65	
	5		11.46	
	3		8.89	
	2		6.6	
HIO	aq.		38.	
HIO ₃	c		56.77	<i>S</i> — 2.17
	aq.		54.6	
HIO ₃ ----	aq.		158.5	
H ₂ IO ₆ ---	aq.		171.4	
H ₃ IO ₆ --	aq.		182.1	
H ₄ IO ₆ -	aq.		174.4	
H ₅ IO ₆	c		184.4	<i>S</i> — 1.38 ₂₀₀₀
	aq.		183.0	
I ₂ O ₅ ·HIO ₃	c		99.7	<i>S</i> — 4.29 ¹²
ICl	g		— 3.46	
	liq.		6.06	
	c	β	8.15	
	c	α	8.38	<i>F</i> — 2.33
ICl ₃	c		20.0	
IBr	g		— 9.6	
	liq.		2.5	

Element 85

Atomic number 85

Standard state X (c)

Atomic weight (212?)

Sulfur

Atomic number 16 Standard state S (c, rhombic) Atomic weight 32.06

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
S	g	3s ² 3p ⁴ (³ P ₂)	— 66.3	$D^{\circ}_{S_2}$ — 102.6
	liq.	λ	— 0.33	F — 0.35 ¹¹⁹ monoclinic
	liq.	μ	— 0.75	T — 0.41 $_{-\lambda}$
	c	rhombic	0.000	
	c	monoclinic	0.075	T — 0.093 ⁹⁸ \rightarrow rhombic
	S ₂ Cl ₂		— 1.5	
S*	g	3s ² 3p ⁴ (³ P ₁)	— 67.42	
	g	(³ P ₀)	— 67.93	
	g	² D ₁	— 103.20	E° — 36.90
S+	g	3s ² 3p ³ (⁴ S _{3/2})	— 334.53	I° — 237.06
S+ *	g	(² D _{3/2})	— 376.81	E° — 42.28
	g	(² D _{5/2})	— 376.90	E° — 42.37
	g	(² P _{1/2})	— 404.35	E° — 69.82
	g	(² P _{3/2})	— 404.48	E° — 69.95
	g	3s ² 3p ² (³ P ₀)	— 873.5	I° — 537.54
S++	g	(³ P ₁)	— 874.35	E° — 0.85
S++ *	g	(³ P ₂)	— 875.88	E° — 2.38
	g	3s ² 3p (² P _{1/2})	— 1679.9	I° — 804.9
S+++	g	(² P _{3/2})	— 1682.6	E° — 2.71
S++++ *	g	3s ² (¹ S ₀)	— 2767.5	I° — 1086.2
S+++++	g	3s3p (³ P ₁)	— 2885.	I° — 1428.
S+++++	g	3s (² S _{1/2})	— 4303.	I° — 1535.
S+++++	g	2p (¹ S ₀)	— 6325.	I° — 2022.
S--	g		— 146.	
	∞		— 10.0	
S ₂	g	³ $\Sigma^+_{g,u}$	— 29.2	
S ₂ *	g	$\Sigma^+_{g,u}$	— 120.95	E° — 91.75
S ₂ --	aq.		— 9.3	
S ₃ --	aq.		— 7.8	
S ₄ --	aq.		— 5.3	
S ₆	g		— 22.6	
S ₈	g		— 20.0	
	CS ₂		— 3.3	
SO	g		— 6.3	D° — 118.20
SO ₂	g		70.92	
	liq.		77.0	V — 6.07 ⁻¹⁰
	c			F — 1.9 ⁻⁷³
	2000		79.48	S — 8.56
	1000		79.15	S — 8.23
	500		78.81	S — 7.89
	200		78.37	S — 7.45
	100		78.04	S — 7.12
	75		77.92	S — 6.99
	c		568.54	
SO ₂ ·7H ₂ O				

Sulfur

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
SO ₂	g	β , "wool-like" α , "ice-like"	93.9	V — 10.3.
	liq.		104.2	S 41.18 ₆₀₀₀
	c		105.2	S 40.25 ₆₀₀₀
	c		106.0	V_s — 12.1
SO ₂ --	aq.		148.5	
SO ₄ --	∞		215.8	
S ₂ O ₃ --	aq.		145.5	
S ₂ O ₄ --	aq.		162.	
S ₂ O ₅ --	aq.		229.6	
S ₂ O ₆ --	aq.		280.2	
S ₂ O ₇	c		193.4	S 56.7
S ₂ O ₈ --	aq.		323.3	
S ₃ O ₆ --	aq.		279.	
S ₄ O ₆ --	aq.		272.3	
S ₆ O ₆ --	aq.		269.5	
HS-	aq.		3.9	
H ₂ S	g		5.3	
	liq.			V — 4.5 ⁻⁶¹
	c			F — 0.4 ⁻¹¹⁰
	aq.		9.9	S 4.6
H ₂ S·6H ₂ O	c		431.4	
H ₂ S ₂	g		— 8.94	V — 8.54
	liq.		— 0.4	
	c			F — 1.80 ⁻⁸⁰
H ₂ S ₃	liq.		2.6	
HSO ₃ -	aq.		149.0	
H ₂ SO ₃	200		146.74	
HSO ₄ -	aq.		213.3	
H ₂ SO ₄	liq.		193.75	S — 17.75 ₂₀₀
	c		196.34	F — 2.55 ¹⁰
	∞		215.8	
	20000		214.74	
	15000		214.54	
	10000		214.38	
	8000		214.16	
	6000		213.92	
	4000		213.56	
	2000		212.96	
	1000		212.41	
	800		212.25	
	600		212.08	
	400		211.84	
	200		211.5	
	100		211.29	
	80		211.23	

Sulfur

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
H ₂ SO ₄	60		211.17	
	50		211.12	
	40		211.05	
	30		210.93	
	20		210.79	
	15		210.39	
	10		209.63	
	9		209.35	
	8		209.00	
	7		208.63	
	6		208.12	
	5		207.50	
	4		206.57	
	3		205.37	
	2		203.51	
	1.5		202.54	
	1.0		200.46	
	0.5		197.50	
	5(C ₂ H ₅) ₂ O		205.13	
	10(C ₂ H ₅) ₂ O		206.35	
	20(C ₂ H ₅) ₂ O		208.11	
H ₂ SO ₄ ·H ₂ O	liq.		268.74	
	c		273.28	$F - 4.45^{1.6}$
H ₂ S ₂ O ₄	aq.		161.1	
H ₂ S ₂ O ₆	600		280.7	
H ₂ S ₂ O ₇	liq.		299.6	$F - 2.64^{30}$
	c		302.25	$S - 53.92_{1650}$
H ₂ S ₂ O ₈	aq.		318.5	
H ₂ S ₂ O ₈	aq.		269.2	
SF ₆	g		262.	
	liq.			$F - 1.39^{-54.8}$
	c			$V_s - 5.64^{-63.8}$
SCL ₄	liq.		13.7	
S ₂ Cl ₂	g		5.65	$V - 8.65$
	liq.		14.3	
S ₂ Cl ₄	liq.		24.1	
SOCl ₂	g		42.7	$V - 7.48^{76}$
	liq.		50.2	$S - 39.2$
SO ₂ Cl ₂	g		86.2	$V - 6.7^{88}$
	liq.		92.9	
S ₂ O ₄ Cl ₂	g		153.3	$V - 13.2$
	liq.		166.5	$S - 222.4_{4\text{ KOH (aq.)}}$
SO ₂ HCl	liq.		142.3	$S - 40.3_{200}$
S ₂ Br ₂	liq.		4.0	
SOBr ₂	liq.			$V - 10.4^{140}$

Selenium

Atomic number 34

Standard state Se (c, hexagonal)

Atomic weight 78.96

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Se	g	4p ³ 5p (³ P ₂)	- 61.	$D^{\circ}_{Se_2}$ - 92.
	liq.			F - 1.6 ³⁰⁰
	c	I, hexagonal	0.000	
	c	II, red, monoclinic	- 0.2	T 0.18 ¹⁸⁰ - I
Se*	gls.	vitreous	- 1.1	T 1.08 ¹⁷⁸ - I
	g	4p ³ 5p (³ P ₁)	- 66.44	E° - 5.44
	g	(³ P ₀)	- 68.22	E° - 7.22
	g	(D ₂)	- 88.24	E° - 27.24
	g	¹ S ₀	- 127.48	E° - 66.48
Se ⁺	g	4s ² 4p ³ (⁴ S ¹ / ₂)	- 286.4	I° - 223.92
Se ²⁻	aq.		- 37.3	
Se ₂	g		- 29.5	
Se ₃	g		- 32.5	
Se ₈	g		- 34.8	
SeO ₂	c		56.36	S - 0.93 ³⁰⁰⁰
	2000		55.43	
SeO ₃ ²⁻	aq.		123.3	
SeO ₄ ²⁻	aq.		146.4	
HSe ⁻	aq.		- 26.4	
H ₂ Se	g		- 18.5	
	aq.		- 16.1	S 2.43
HSeO ₃ ⁻	aq.		124.8	
HSeO ₄ ⁻	aq.		144.2	
H ₂ SeO ₃	c		119.69	S - 4.11
	aq.		123.8	
H ₂ SeO ₄	liq.		126.8	S 16.80 ¹⁸ ₈₀₀
	c		130.25	S 13.35 ¹⁸ ₈₀₀
	∞		146.4	
	4000		144.6	
	1200		143.8	
	800		143.6	
	400		143.2	
	200		142.9	
	1		131.6	
	liq.		200.0	S 12.02 ¹⁸ ₈₀₀
H ₂ SeO ₄ ·H ₂ O	c		204.5	S 7.45 ¹⁸ ₈₀₀
	g		246.	
SeF ₆	liq.			F - 2.0 ^{-34.6}
	c			V_8 - 6.60 ^{-46.6}
SeCl ₂	g		10.0	
Se ₂ Cl ₂	liq.		22.13	
SeCl ₄	c		46.12	
SeO ₂ ·SO ₂	c		168.5	S 321.1 ¹⁸ ₄₀₀₀

Tellurium

Atomic number 52

Standard state

Te (c, II)

Atomic weight 127.61

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Te	g	5s ² 5p ⁴ (³ P ₂)	- 55.	$D^{\circ}_{Te_2}$ - 85.
	liq.			F - 4.27 ⁴⁴⁶
	c	I		T 0.80 ³⁴³ ± .11
	c	II	0.000	
Te*	amorp.	precipitated	- 2.7	
	g	5s ² 5p ⁴ (³ P ₀)	- 73.20	E° - 18.20
	g	(³ P ₁)	- 73.60	E° - 18.60
	g	¹ D ₂	- 85.06	E° - 30.06
Te ⁺	g	¹ S ₂	-106.0	E° - 51.0
	g		-256.	I° -200.
Te ₂	g		- 24.0	V - 22.0 ¹³⁰⁰
TeO ₂	c		77.58	
	HCl(aq.)		76.6	
TeO ₃ --	aq.		141.0	
TeO ₄ --	aq.		168.9	
H ₂ Te	g		- 34.2	S 58.2 ¹⁶ FeCl ₂ (aq.)
H ₂ TeO ₃	c		145.0	S 0.0
	aq.		145.0	
H ₂ TeO ₄	400		165.3	
H ₂ TeO ₄ ·2H ₂ O	c		305.4	S - 3.35 ¹⁴ ₆₀₀
TeF ₆	g		315.	
	liq.			F - 1.9 ^{-37.8}
TeCl ₄	c			V_3 - 6.74 ^{-88.9}
	c		77.4	
TeBr ₄	c		49.3	S 7.05 NaC ₂ H ₃ O ₂ (aq.)
2TeO ₂ ·SO ₃	c		291.7	S 61.4 ¹⁶ KOH (aq.)

Polonium

Atomic number 84

Standard state

Po (c)

Atomic weight (210)

Nitrogen

Atomic number 7

Standard state N₂ (g)

Atomic weight 14.008

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
N	g	2s ² 2p ³ (⁴ S _{3/2})	— 85.1	$D^{\circ}N_2$ — 169.3
N*	g	(² D _{3/2})	— 139.76	E° — 54.66
	g	(² P _{1/2})	— 167.11	E° — 82.01
N ⁺	g	2s ² 2p ² (³ P ₀)	— 420.75	I° — 334.20
N ⁺ *	g	(³ P ₁)	— 420.89	E° — 0.14
	g	(³ P ₂)	— 421.13	E° — 0.38
	g	¹ D ₂	— 469.36	E° — 43.61
N ⁺⁺	g	2s ² 2p (² P _{1/2})	— 1102.20	I° — 680.0
N ⁺⁺ *	g	² (P _{3/2})	— 1102.70	E° — 0.496
N ⁺⁺⁺	g	2s ² (¹ S ₀)	— 2197.1	I° — 1093.4
N ⁺⁺⁺⁺	g	1s ² 2s (² S _{1/2})	— 3975.7	I° — 1777.3
N ⁺⁺⁺⁺⁺	g	1s ² (¹ S ₀)	— 6225.0	I° — 2247.8
N ⁺⁺⁺⁺⁺⁺	g	1s (² S _{1/2})	— 18831.	I° — 12605.
N ⁺⁺⁺⁺⁺⁺⁺	g		— 34020.	I° — 15187.
N ₂	g	¹ Σ	0.000	
N ₂	liq.	I		V — 1.336 ⁻¹⁹⁸
	c			F — 0.169 ⁻²¹⁰
N ₂ *	g	A, ³ Σ	— 188.5	E° — 188.5
	g	a	— 196.4	E° — 196.4
	g	B, ³ Π	— 215.4	E° — 215.4
	g	b	— 295.0	E° — 295.0
	g	b ¹	— 297.2	E° — 297.2
	g	C, ³ Π	— 299.5	E° — 299.5
N ₂ ⁺	g	² Σ	— 362.5	I° — 361.
	g	A, ² Σ	— 436.2	E° — 73.7
N ₃ ⁻	aq.		— 58.4	
NO	g		— 21.6	
	liq.			V — 3.293 ⁻¹⁸²
	c			F — 0.550 ⁻¹⁶⁴
NO*	g	A, ² Σ	— 147.3	E° — 125.7
	g	B, ² Π	— 150.7	E° — 129.1
	g	C, ² Σ	— 170.3	E° — 148.7
NO ₂	g		— 8.03	
NO ₂ ⁻	aq.		25.3	
NO ₃	g		— 13.	
NO ₃ ⁻	∞		49.19	
N ₂ O	g		— 19.65	
	liq.			V — 4.0 ⁻⁸⁹
	c			V_s — 5.69 ⁻¹¹³
	aq.		— 13.4	S — 6.2 ⁰
N ₂ O·6H ₂ O	c		405.4	D — 14.8 ⁰ ·H ₂ O (liq.)
N ₂ O ₂ ⁼⁼	aq.		— 3.5	
N ₂ O ₃	g		— 20.0	
	liq.			V — 9.40 ²⁰

Nitrogen

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
N_2O_4	g		— 3.06	
	liq.		— 12.2	V — 9.2 ²⁰
	c			F — 3.0 ⁻¹⁰
N_2O_5	g		— 0.6	
	c		13.1	S 16.7
NH	g	³ Σ	— 33.9	D* — 102.2
NH*	g		— 118.6	E* — 84.69
NH ₃	g		11.00	
	liq.		16.07	V — 5.56 ⁻³³
	c			F — 1.42 ⁻⁷⁸
	∞		19.35	
	200		19.35	S 8.35 ₂₀₀
	100		19.36	
	50		19.35	
	20		19.31	
	10		19.27	
	4		19.07	
	2.33		18.97	
	1.5		18.49	
	1.0		17.6	
NH ₄ ⁺	g		20.	
	∞		31.455	
N ₂ H ₄	aq.		— 4.5	
N ₂ H ₄ H ⁺	aq.		5.1	
N ₂ H ₄ H ₂ ⁺⁺	aq.		5.1	
HN ₃	aq.		— 54.6	
NH ₃ HN ₃	c		— 20.2	C 157.0
	aq.		— 26.9	S — 6.74 ¹⁷ ₄₀₀
HNO ₂	aq.		28.5	
	g		34.4	V — 7.2
	liq.		41.66	S — 7.44 ₃₀₀
	c			F — 0.60 ⁻⁴⁷
	∞		49.19	
	6400		49.154	
	3200		49.142	
	1600		49.129	
	800		49.116	
	400		49.105	
	200		49.1	
	100		49.104	
	50		49.124	
	25		49.162	
	20		49.12	
	10		48.98	
	5		48.33	

Nitrogen

Formula	State	Description	Q_f , kcal. mole^{-1}	Q , kcal. mole^{-1}
HNO_3	3	in diethyl ether	47.37	
	2		46.44	
	1		44.95	
	$30(\text{C}_2\text{H}_5)_2\text{O}$		51.16	
	$20(\text{C}_2\text{H}_5)_2\text{O}$		51.00	
	$10(\text{C}_2\text{H}_5)_2\text{O}$		50.74	
NH_2OH	$5(\text{C}_2\text{H}_5)_2\text{O}$		50.26	$S - 3.8$
	liq.		25.5	
	aq.		21.7	
$\text{NH}_2\text{OH H}^+$	aq.		31.0	
NH_4OH	aq.		87.67	
NH_4OH	aq.		90.1	
$\text{H}_2\text{N}_2\text{O}_2$	aq.		8.4	
NH_4NO_2	c		61.5	$S - 4.75^{13}_{400}$
	aq.		56.8	$N - 9.1$
NH_4NO_3	c	I		$T - 1.02^{125}_{-II}$
	c	II		$T - 0.32^{83}_{-III}$
	c	III		$T - 0.399^{82}_{-IV}$
	c	IV	87.13	$S - 6.32^{16}_{700}$
	c	V		$T - 0.13^{-12}_{-IV}$
	∞		80.66	
	1000		80.684	
	500		80.710	
	200		80.81	
	100		80.914	
	50		81.143	
	25		81.556	
$\text{NH}_4\text{OH} \cdot \text{HNO}_3$	20		81.63	
	10		82.06	
	5		82.68	
	3		82.99	
	2.5		83.32	
	c		86.9	$S - 5.93^{11}_{300}$
	aq.		81.	$N - 9.42_{400}$
	c		62.0	$S - 1.92_{400}$
	aq.		63.9	
	aq.		54.4	$N - 9.75$
	aq.		103.4	$N - 9.70$
	liq.		171.5	$D - 5.9^{-20}$
NOF	c			$F - 2.0^{-19}$
	liq.			$V - 4.60^{-60}$
NO_2F	liq.			$V - 4.32^{-72}$
NH_4F	c		111.6	$S - 1.5$
	aq.		110.1	$N - 19.2_{100}$
NCl_3	CCl_4		— 55.0	

Nitrogen

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
NOCl	g		— 12.8	<i>S</i> — 37.1 _{2KOH(aq.)}
	liq.		— 18.9	<i>V</i> — 6.1 ⁻¹⁶
NH ₄ Cl	g		44.	
	c	I		<i>T</i> — 1.03 ¹⁸⁴ → II
	c	II	74.95	<i>S</i> — 3.92 ₂₀₀
	c	III		<i>T</i> — 0.356 ⁻³¹ → II
	∞		71.132	
	1000		71.089	
	500		71.069	
	400		71.06	<i>N</i> — 12.30 ₂₀₀
	200		71.032	
	100		71.020	
	50		71.031	
	25		71.079	
	10		71.58	
N ₂ H ₄ ·HCl	c		50.0	<i>S</i> — 5.44 ¹⁷ ₅₀₀
	aq.		44.6	<i>N</i> — 9.65 ¹⁷
N ₂ H ₄ ·2HCl	c		90.3	<i>S</i> — 6.20 ¹⁹ ₆₀₀
	aq.		84.1	<i>N</i> — 9.7
NH ₄ Cl·3NH ₃	c		130.1	<i>D</i> — 22.8
NH ₄ Cl·6NH ₃	liq.		180.6	<i>D</i> — 17.0
NH ₂ OH·HCl	c		74.0	<i>S</i> — 3.65 ₄₅₀
	aq.		70.4	<i>N</i> — 9.26 ₄₀₀
NH ₄ ClO ₄	c		78.1	<i>S</i> — 6.36 ²⁰ ₂₀₀
	aq.		71.7	<i>N</i> — 12.90 ₆₀₀
NOBr	g		— 17.7	
	liq.		— 11.6	<i>S</i> — 23.8 _{2KOH(aq.)}
NOBr ₂	g		— 4.9	<i>V</i> — 6.6
	liq.		1.7	<i>S</i> — 52.5 _{4KOH(aq.)}
NH ₄ Br	c	I		<i>T</i> — 0.76 ¹³⁸ → II
	c	II	64.58	<i>S</i> — 4.45 ₂₀₀
	aq.		60.13	
NH ₄ Br ₂	c		69.73	<i>D</i> — 12.8
NH ₄ Br·NH ₃	c		83.5	<i>D</i> — 7.95
NH ₄ Br·3NH ₃	c		121.2	<i>D</i> — 7.9
NH ₄ Br·6NH ₃	c		170.9	<i>D</i> — 5.6
NH ₄ I	c	I	48.39	<i>S</i> — 3.56 ₂₀₀
	c	II		<i>T</i> — 0.70 ⁻¹⁸ → I
	aq.		44.83	
NH ₄ I·NH ₃	c		67.6	<i>D</i> — 8.2
NH ₄ I·3NH ₃	c		103.5	<i>D</i> — 7.0
NH ₄ I·6NH ₃	c		153.5	
NS	c		— 31.9	
N ₂ O ₅ (SO ₃) ₂	c		253.	<i>S</i> — 107 ²² _{2KOH(aq.)}
NH ₄ HS	c		38.9	<i>S</i> — 3.3

Nitrogen

Formula	State	Description	Q_f , kcal. mole^{-1}	Q , kcal. mole^{-1}	
NH_4HS	200		35.55	<i>N</i>	6.35 ₁₀₀
$(\text{NH}_4)_2\text{S}$	400		55.00	<i>N</i>	6.50 ₂₀₀
NH_4S_4	c		31.9	<i>S</i> —	4.3 ¹²
	aq.		28.1		
$(\text{NH}_4)_2\text{S}_5$	c		64.7	<i>S</i> —	83 ¹²
	aq.		56.2		
NH_4S_2	c		32.2	<i>S</i> —	4.3 ¹²
	aq.		27.9		
NH_4HSO_3	aq.		180.35	<i>N</i>	14.89
NH_4HSO_4	c		244.64	<i>S</i> —	0.02 ₂₀₀
	800		245.20		
	400		244.88		
	200		244.62		
	100		244.43		
	50		244.32		
	20		244.20		
	10		243.83		
$\text{NH}_4\text{OH} \cdot \text{H}_2\text{SO}_4$	aq.		244.4	<i>N</i>	11.07 ₄₀₀
$(\text{NH}_4)_2\text{SO}_3$	c		212.3	<i>S</i> —	1.54 ⁹ ₈₅₀
	aq.		211.1	<i>N</i>	25.40 ⁸ ₄₄₀
$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$	c		283.6	<i>S</i> —	4.3 ¹²
$(\text{NH}_4)_2\text{SO}_4$	c		281.46	<i>S</i> —	2.38 ₄₀₀
	∞		278.71		
	800		279.06		
	400		279.08	<i>N</i>	28.96 ₄₀₀
	200		279.15		
	100		279.27		
	50		279.46		
	30		279.65		
	10		279.90		
$\text{N}_2\text{H}_4 \cdot \text{H}_2\text{SO}_4$	c		227.8		
	aq.		219.3	<i>N</i>	11.29 ¹⁷
$(\text{NH}_2\text{OH})_2 \cdot \text{H}_2\text{SO}_4$	c		287.7	<i>S</i> —	0.96 ₈₀₀
	aq.		276.6	<i>N</i>	21.6 ₆₀₀
$(\text{NH}_4)_2\text{S}_2\text{O}_5$	c		299.5	<i>S</i> —	6.3 ₄₀₀
	aq.		292.3		
$(\text{NH}_4)_2\text{S}_2\text{O}_8$	c		395.4	<i>S</i> —	9.2 ¹⁶ ₁₀₀₀
	aq.		386.2		
$(\text{N}_2\text{H}_4)_2 \cdot \text{H}_2\text{SO}_4$	aq.		225.8	<i>N</i>	22.33
NSe	c		— 42.3	<i>D</i> —	42.3
NH_4HSe	aq.		5.1		
$(\text{NH}_4)_4\text{Se}$	aq.		25.6		

Phosphorus

Atomic number 15 Standard state P (c, I, yellow) Atomic weight 31.02

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
P	c	I, yellow	0.000	
	c	II, yellow		T — 1.27 ⁻⁸⁰ _I
	c	red	4.22	T — 4.22 _I
	liq.	yellow		F — 0.155 ⁴⁴ _I
	g	3s ² 3p ³ (⁴ S _{3/2})	— 31.6	D_{P_2} — 45.5 ¹⁰⁰⁰
P+	g	3s ² 3p ² (³ P ₀)	— 279.36	I^* — 246.31
P+ *	g	(³ P ₁)	— 279.83	E^* — 0.471
	g	(³ P ₂)	— 280.70	E^* — 1.338
	g	3s ² 3p3d (³ D ₁)	— 465.12	E^* — 185.76
	g	(³ D ₂)	— 465.18	E^* — 185.82
	g	(³ D ₃)	— 465.28	E^* — 185.915
	g	(³ P ₀)	— 498.06	E^* — 218.70
	g	(³ P ₁)	— 498.03	E^* — 218.67
	g	(³ P ₂)	— 497.89	E^* — 218.53
	g	3s ² 3p4s (³ P ₀)	— 526.17	E^* — 246.81
	g	(³ P ₁)	— 526.30	E^* — 246.94
	g	(³ P ₂)	— 527.39	E^* — 248.03
	g	3s ² 3p (³ P _{1/2})	— 737.72	I^* — 456.91
	g	(³ P _{1/2})	— 737.87	E^* — 0.159
P++	g	3s ² p (³ P ₀)	— 1431.87	I^* — 692.72
P++ *	g	(³ P ₁)	— 1432.52	E^* — 0.651
P+++	g	(³ P ₂)	— 1433.87	E^* — 1.983
P+++ *	g	3s (² S _{1/2})	— 2420.20	I^* — 986.88
P++++	g	2p ⁶ (¹ S ₀)	— 3911.92	I^* — 1490.28
P ₂	g		— 20.7	D_{P_2} — 31.5 ⁸⁰⁰
	CS ₂		— 0.92	
P ₄	g		— 13.2	
PO ₃ ⁻	aq.		235.2	
PO ₃ ---	aq.		216.4	
PO ₄ ---	aq.		297.6	
P ₂ O ₃	c	"volatile"	360.0	
	amorp.		367.0	
	gls.		371.7	
P ₂ O ₇ ----	aq.		537.2	
P ₄ O ₁₀	g		700.	
PH	g	³ Σ ⁻	— 30.	D^* — 53.
PH*	g	³ Π	— 113.	E^* — 83.
PH ₃	g		2.3	
	liq.			V — 3.9 ⁻⁸⁰
PH ₃ ·6H ₂ O	c		426.0	D — 13.5 ⁰ → H ₂ O (liq.)
P ₂ H	c		11.9	
HPO ₃ ⁻	aq.		128.9	
HPO ₃	c		224.8	S 9.76
	aq.		234.6	

Phosphorus

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HPO ₃ --	aq.		227.	
HPO ₄ --	aq.		305.6	
H ₂ PO ₄ -	aq.		142.6	
H ₂ PO ₃ -	aq.		228.	
H ₂ PO ₄ -	aq.		307.1	
H ₃ PO ₃	c		141.4	<i>S</i> — 0.17 ¹⁹ ₁₈₀
	liq.		139.0	<i>S</i> — 2.18 ¹⁹ ₁₈₀
	450		141.41	
	250		141.2	
	220		141.17	
	110		140.70	
	55		140.45	
H ₃ PO ₃	c		228.93	<i>S</i> — 0.13 ¹⁹ ₁₈₀
	liq.		225.86	<i>S</i> — 2.94 ¹⁹ ₁₈₀
	aq.		228.8	
H ₃ PO ₄	c		303.37	<i>S</i> — 2.69 ¹⁹ ₁₈₀
	liq.		300.85	<i>S</i> — 5.22 ¹⁹ ₁₈₀
	400		306.16	
	200		306.1	
	100		306.02	
	50		305.92	
	20		305.69	
	9		305.26	
	3		304.05	
	1		302.49	
H ₃ PO ₄ · $\frac{1}{2}$ H ₂ O	c		340.4	<i>S</i> — 0.14 ¹³ ₂₀₀
	liq.		344.1	<i>S</i> — 3.78 ¹³ ₂₀₀
HP ₂ O ₇ ---	aq.		540.0	
H ₂ P ₂ O ₆ --	aq.		385.1	
H ₂ P ₂ O ₇ --	aq.		540.2	
H ₂ P ₂ O ₇ -	aq.		540.6	
H ₄ P ₂ O ₆	aq.		384.3	
H ₄ P ₂ O ₆	c			<i>S</i> — 2.2
	liq.			<i>S</i> — 6.6
H ₄ P ₂ O ₇	c		513.7	<i>S</i> — 7.93
	liq.		529.4	<i>S</i> — 10.22
	aq.		539.6	
H ₄ P ₂ O ₇ · $1\frac{1}{2}$ H ₂ O	c		637.5	<i>S</i> — 4.49
	liq.		634.4	<i>S</i> — 7.63
PF ₃	g			<i>S</i> — 107.7 _{KOH(ad.)}
PCl ₃	g		70.0	<i>V</i> — 6.9
	liq.		76.9	
PCl ₅	g		91.0	<i>V</i> ₃ — 15.5
	c		106.5	
POCl ₃	g		138.4	<i>V</i> — 8.2 ¹⁰⁷

Phosphorus

Formula	State	Description	Q_f , kcal. mole^{-1}	Q , kcal. mole^{-1}
POCl ₃	liq.		147.1	<i>S</i> 72.2 ¹⁹ ₁₀₀₀
	c		150.3	<i>F</i> — 3.2 ²
PH ₄ Cl	g		40.8	
	c		67.8	
PBr ₃	liq.		45.	
PBr ₅	c		60.6	
POBr ₃	c		106.9	
PH ₄ Br	c		34.2	
PI ₃	c		9.9	
PI ₅	c		10.9	<i>S</i> 3.3 _{CS₂}
	CS ₂		14.2	
PH ₄ I	c		20.6	
P ₂ N ₅	c		75.0	<i>C</i> 1099.4
NH ₄ H ₂ PO ₄	400		338.9	
(NH ₄) ₂ HPO ₄	500	2NH ₄ ⁺ (aq.) + HPO ₄ ²⁻ (aq.)	368.5	
	500	2NH ₄ ⁺ (aq.) + H ⁺ (aq.) + PO ₄ ³⁻ (aq.)	360.5	
(NH ₄) ₃ PO ₄	600		397.5	

Arsenic

Atomic number 33 Standard state As (c, α, metallic) Atomic weight 74.91

As	g	4p ³ (⁴ S _{3/2})	— 30.3	<i>D</i> _{A₂} — 35.0 ¹⁰⁰⁰
	liq.			<i>F</i> _α — 5.1 ⁸¹⁸
	c	α, metallic	0.000	
	amorp.	β	— 1.0	<i>T</i> 1.0 _α
	c	γ, yellow	— 3.5	<i>T</i> 3.5 _α
As*	g	4p ³ (² D _{3/2})	— 60.45	<i>E</i> [*] — 30.15
	g	(² D _{5/2})	— 61.37	<i>E</i> [*] — 31.07
As ⁺	g	4p ² (³ P ₀)	— 262.	<i>I</i> [*] — 230.
As ⁺ *	g	(³ P ₁)	— 265.0	<i>E</i> [*] — 3.00
	g	(³ P ₂)	— 269.2	<i>E</i> [*] — 7.23
	g	(¹ D ₂)	— 298.0	<i>E</i> [*] — 35.97
As ⁺⁺	g	4p (² P _{1/2})	— 726.9	<i>I</i> [*] — 463.4
As ⁺⁺ *	g	(² P _{3/2})	— 734.4	<i>E</i> [*] — 7.53
As ⁺⁺⁺	g	4s ⁴ p (³ P ₀)	— 1355.2	<i>I</i> [*] — 626.9
As ⁺⁺⁺ *	g	(³ P ₁)	— 1358.5	<i>E</i> [*] — 3.27
	g	(³ P ₂)	— 1365.7	<i>E</i> [*] — 10.47
As ⁺⁺⁺⁺	g	(² S _{1/2})	— 2334.3	<i>I</i> [*] — 977.6
As ⁺⁺⁺⁺ *	g	3p ⁶ (¹ S ₀)	— 3773.7	<i>I</i> [*] — 1438.0
As ₂	g		— 25.7	<i>D</i> ^v _α — 25.0 ¹⁰⁰⁰

Arsenic

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
As ₄	g	octahedral monoclinic	— 30.4	V_{S_n} — 31.8 ⁴⁰⁰
AsO ₃ ---	aq.		141.9	
AsO ₄ ---	aq.		209.2	
As ₂ O ₃	g		125.	$D_{As_2O_3}$ — 17.0 ¹²⁰⁰
	c		154.1	S 7.50 _{1N NaOH (200)}
	c		148.	
	aq.		146.6	
As ₂ O ₅	c		217.9	S 80.8 _{12N NaOH (200)}
	aq.		223.9	
As ₄ O ₆	g		268.0	
AsH ₃	g		— 43.6	
AsH ₃ ·6H ₂ O	c		384.4	D — 17.8°-H ₂ O (liq.)
HAsO ₃ --	aq.		155.4	
HAsO ₄ --	aq.		214.6	
H ₂ AsO ₃ -	aq.		168.4	
H ₂ AsO ₄ -	aq.		215.7	
H ₂ AsO ₃	aq.		175.3	
H ₂ AsO ₄	c		214.9	S — 0.40 ₂₀₀
	aq.		214.5	
AsF ₃	liq.			V — 5.00 ⁻⁴³
	c			F — 2.74 ⁻⁸⁰
AsCl ₃	g		64.0	V — 7.5
	liq.		71.5	
AsBr ₃	g		33.	V — 10. ²²⁰
	liq.		43.1	F — 2.8 ³²
	c		45.9	S 59.8 ⁹ KOH (aq.)
AsI ₃	g		— 7.8	
	liq.		11.4	V — 19.2
	c		13.6	F — 2.2
As ₂ S ₃	c		20.	

Antimony

Atomic number 51

Standard state Sb (c, trigonal)

Atomic weight 121.76

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Sb	g	5s ² 5p ³ (⁴ S _{3/2})	— 40.	
	liq.			F — 4.8 ⁶³⁰
	c	trigonal	0.000	
Sb*	c	"explosive"	— 2.32	
	g	5s ² 5p ³ (² D _{3/2})	— 64.23	E^* — 24.23
	g	(² D _{5/2})	— 68.05	E^* — 28.05
	g	(² P _{1/2})	— 86.67	E^* — 46.67
	g	(² P _{3/2})	— 92.56	E^* — 52.56
Sb ⁺	g	5s ² 5p ² (³ P ₀)	— 234.0	I^* — 192.5
Sb ⁺⁺	g	5s ² 5p (² P _{1/2})	— 669.2	I^* — 443.7
Sb ⁺⁺ *	g	(² P _{3/2})	— 687.9	E^* — 18.74
Sb ⁺⁺⁺	g	5s ² (¹ S ₀)	— 1240.7	I^* — 570.1
Sb ⁺⁺⁺⁺	g	5s (² S _{1/2})	— 2256.1	I^* — 1013.9
Sb ⁺⁺⁺⁺⁺	g	4p ⁶ (¹ S ₀)	3536.6	I^* — 1279.
Sb ₂	g		— 52.	
SbO	g		— 17.	
SbO ₂ ---	aq.		187.6	
Sb ₂ O ₃	c	I, orthorhombic	165.4	S 20.2 ⁹ _{HF(100)}
	c	II, octahedral	166.6	S 19.0 ⁹ _{HF(100)}
	aq.		166.0	
Sb ₂ O ₄	c		213.0	
Sb ₂ O ₅	c		230.0	
Sb ₂ O ₆	aq.		228.0	
	g		186.6	V_{SII} — 47.3 ⁶⁰⁰
Sb ₂ O ₆	liq.			F_{II} — 29.5
	c		660.	
Sb ₂ O ₁₂	c		216.6	S — 1.6 ⁹ ₂₀₀
SbF ₃	c		214.9	
H ₂ SbF ₆	aq.		443.5	
	g		77.4	V — 10.95 ¹²⁸
SbCl ₃	liq.		88.4	F — 3.01 ⁷³
	c		91.4	
	g		93.7	V — 11.05 ⁶⁷
SbCl ₅	liq.		104.9	
	c		107.3	F — 2.45 ⁻⁴
SbOCl	c		89.2	
Sb ₂ O ₃ Cl ₂	c		346.1	
SbBr ₃	liq.		56.5	F — 3.52 ¹⁰⁰
	c		60.0	S 3.6 ²⁸ _{CS₂}
	CS ₂		56.4	
SbI ₃	c		22.8	
	aq.		22.0	
Sb ₂ S ₃	c	orange ppt.	35.7	

Antimony

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Sb ₂ S ₃	c	black	35.8	S 118.7 NaOH(aq.) D — 14.1 D — 12.1 D — 9.2 D — 7.6 D — 7.5
	c	lilac (?)	31.5	
	c	brown (?)	37.1	
Sb ₂ (SO ₄) ₃	c		572.2	
SbF ₃ ·NH ₃	c		241.7	
SbF ₃ ·2NH ₃	c		264.7	
SbF ₃ ·3NH ₃	c		284.9	
SbF ₃ ·4NH ₃	c		303.5	
SbF ₃ ·6NH ₃	c		340.4	

Bismuth

Atomic number 83

Standard state Bi (c)

Atomic weight 209.00

Bi	g	6s ² 6p ³ (⁴ S _{3/2})	— 47.8	F — 2.64 ²⁷¹
	liq.		0.000	
Bi*	c			
	g	6s ² 6p ³ (² D _{3/2})	— 80.30	E^* — 32.50
	g	(² D _{5/2})	— 91.74	E^* — 43.94
Bi ⁺	g	6s ² 6p ² (³ P ₀)	— 216.0	I^* — 166.71
Bi ⁺ *	g	(³ P ₁)	— 253.9	E^* — 37.93
	g	(³ P ₂)	— 264.5	E^* — 48.47
Bi ⁺⁺	g	6s ² 6p (² P _{1/2})	— 607.	I^* — 390.
Bi ⁺⁺ *	g	(² P _{3/2})	— 651.	E^* — 44.
Bi ⁺⁺⁺	g	6s ² (¹ S ₀)	— 1178.	I^* — 569.
Bi ₂	g		— 76.2	D^* — 18.5
BiO	c		49.5	
Bi ₂ O ₃	c		137.1	
	amorp.	hydrated	136.8	
Bi(OH) ₃	c		171.1	
BiCl ₃	c		90.6	
	HCl (25)		84.5	
BiOCl	c		89.8	
BiI ₃	c		24.	S 2.88
	aq.		27.	
Bi ₂ S ₃	c		26.0	
Bi ₂ (SO ₄) ₃	c		408.0	S 54.6 NaOH(aq.)

Carbon

Atomic number 6

Standard state C (c, diamond)

Atomic weight 12.00

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
C	g	2s ² 2p (³ P ₀)	- 170.0 + a†	
	liq.			F - 11.3600 graphite
	c	diamond	0.000	
	c	β graphite	0.22	
	c	α graphite	0.49	
	c	"carbonado"	- 0.10	
	"amorp."	"acetylene" carbon	- 0.3	
	"amorp."	"gas" carbon	- 1.5	
	"amorp."	charcoal	- 2.0	
	"amorp."	"Glanzkohlenstoff," density = 2.07	- 2.1	
	"amorp."	"Glanzkohlenstoff," density = 2.0	- 2.3	
	"amorp."	"Glanzkohlenstoff," density = 1.86	- 3.2	
C*	g	2s ² 2p (³ P ₁)	- 170.04 + a	E* - 0.042
	g	(³ P ₂)	- 170.12 + a	E* - 0.120
	g	(¹ D ₂)	- 197.63 + a	E* - 27.63
	g	(¹ S ₀)	- 230.23 + a	E* - 60.23
C+	g	2s ² 2p (² P _{1/2})	- 430.55 + a	I* - 259.10
C+ *	g	(² P _{3/2})	- 430.82 + a	E* - 0.267
	g	2s2p ² (⁴ P _{1/2})	- 550.58 + a	E* - 120.03
	g	(⁴ P _{3/2})	- 550.64 + a	E* - 120.09
	g	(⁴ P _{5/2})	- 550.69 + a	E* - 120.17
	g	² D _{3/2}	- 643.86 + a	E* - 213.313
	g	² D _{5/2}	- 643.86 + a	E* - 213.317
	g	2s ² (¹ S ₀)	- 991.84 + a	I* - 559.84
	g	2s2p (³ P ₀)	- 1140.77 + a	E* - 148.93
C++	g	(³ P ₁)	- 1140.84 + a	E* - 149.00
	g	(³ P ₂)	- 1141.00 + a	E* - 149.16
	g	2s (² S _{1/2})	- 2092.6 + a	I* - 1099.3
C+++ *	g	2p (² P _{1/2})	- 2276.2 + a	E* - 183.57
	g	(² P _{3/2})	- 2276.5 + a	E* - 183.88
C++++	g	1s ² (¹ S ₀)	- 3574.9 + a	I* - 1480.8
C+++++	g	1s	- 7127. + a	I* - 3552.
C++++++	g		- 18375. + a	I* - 11246.
C ₂	g	³ Π _u	- 177.3 + 2a	D* - 161.8
C ₂ *	g	³ Π _g	- 232.4 + 2a	E* - 55.1
CO	g	¹ Σ ⁺	26.84	C 67.61
	liq.			V - 1.444-191.5
	c	I		F - 0.1997-205.0
	c	II		T - 0.1513-211.6-1

†See text, page 232.

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CO	aq.		29.6	<i>S</i> 2.8
CO*	g	a, ³ Π	— 111.3	<i>E*</i> — 138.1
	g	A, ¹ Π	— 157.4	<i>E*</i> — 184.2
	g	c, ³ Π	— 235.4	<i>E*</i> — 262.2
	g	B, ¹ Σ	— 220.6	<i>E*</i> — 247.4
	g	b, ³ Σ	— 211.9	<i>E*</i> — 238.7
	g	² Σ	— 301.5	<i>I*</i> — 327.
CO ⁺	g		— 359.4	<i>E*</i> — 57.9
CO ⁺ *	g	A ¹ , ² Π	— 431.5	<i>E*</i> — 130.
	g	B ¹ , ² Σ	— 94.45	
CO ₂	g		94.45	
	liq.			<i>V</i> — 6.0 ⁻⁵⁴
	c			<i>F</i> — 2.24 ⁻⁵⁴
	aq.		99.21	<i>S</i> 4.76
CO ₂ ·6H ₂ O	c		519.6	<i>D</i> — 14.9 _{-H₂O (liq.)}
CO ₂ ⁺	g		— 237.	<i>I*</i> — 330.
CO ₂ ⁻⁻	g		60.	
	∞	carbonate ion	160.5	
C ₂ O ₄ ⁻⁻	aq.	oxalate ion	195.6	
C ₂ O ₂	liq.	carbon suboxide		<i>V</i> — 6.1 ⁶
CH	g	² Π	— 127.9+ <i>a</i>	<i>E*</i> — 73.1
	g	A, ² Δ	— 194.8+ <i>a</i>	<i>E*</i> — 66.9
	g	B, ² Σ ⁻	— 201.0+ <i>a</i>	<i>D*</i> — 20.0
	g	C, ² Σ ⁺	— 218.5+ <i>a</i>	<i>E*</i> — 90.6
	g		— 286.8	
CH ₄ ⁺	g		18.24	<i>C</i> 212.95
CH ₄	g	methane	18.24	<i>V</i> — 2.18 ⁻¹⁵⁹
	liq.			<i>F</i> — 0.22 ⁻¹⁵³
	c	I		<i>T</i> — 0.018 ⁻²⁴³ _{-I}
	c	II		<i>I*</i> — 336.0
CH ₄ ⁺	g		— 319.2	<i>D</i> — 14.2 _{-H₂O (liq.)}
CH ₄ ·6H ₂ O	c		442.7	<i>C</i> 311.1
C ₂ H ₂	g	acetylene	— 53.9	<i>V</i> — 5.74 ^{-61.5}
	liq.			<i>F</i> — 0.60 ^{-61.5}
	c			<i>S</i> 4.0
	aq.		— 49.9	<i>D</i> — 15.1 _{-H₂O (liq.)}
C ₂ H ₂ ·6H ₂ O	c		371.4	<i>D</i> — 3.03
(C ₂ H ₂) _n	g	polymer	— 158.7	<i>C</i> 338.6
C ₂ H ₄	g	ethylene	— 11.0	<i>V</i> — 3.5 ⁻¹⁰⁴
	liq.			<i>F</i> — 0.70 ⁻¹⁷⁰
	c			<i>D</i> — 15.4 _{-H₂O (liq.)}
	c		414.6	<i>C</i> 373.05
C ₂ H ₄ ·6H ₂ O	g	ethane	20.96	<i>V</i> — 3.33 ^{-88.6}
C ₂ H ₆	liq.			<i>F</i> — 0.668 ^{-159.7}
	c			
CHO ₂ ⁻	aq.	formate ion	99.8	
HCO ₃ ⁻	aq.	bicarbonate ion	164.8	

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HCHO	g	formaldehyde	28.7	C 134.1
HCOOH	g	formic acid	88.65	
	liq.		100.0	C 62.8
	c		103.0	
	200		100.16	F — 3.05 ^{9.0}
	100		100.15	
	50		100.13	
	2.0		100.17	
	1.0		100.17	
	0.5		100.12	
(HCOOH) ₂	g	polymer	191.4	V — 8.57
H ₂ CO ₃	aq.	carbonic acid	167.58	
CH ₃ O ⁻	CH ₃ OH	(CH ₃ OH = H ⁺ + CH ₃ O ⁻)		I — 1.3
CH ₃ OH	g	methyl alcohol	48.44	C 182.75
	liq.		57.45	V — 9.01
	c	I		F — 0.76 ⁻⁹⁸
	c	II		T — 0.14 ⁻¹¹² -I
	∞		59.7	
	33.8		59.19	
	16.0		59.12	
	7.11		58.84	
	4.15		58.57	
	2.67		58.31	
	1.19		57.97	
	0.44		57.74	
HC ₂ O ₄ ⁻	aq.	bioxalate ion	196.	
(CHO) ₂	g	glyoxal	75.	
	c		84.5	C 172.0
	aq.		83.3	S — 1.22
(COOH) ₂	g	oxalic acid, H ₂ C ₂ O ₄	175.9	V ₂ — 21.65
	c		197.6	C 59.7
	300		195.3	S — 2.26 ₃₀₀
	CH ₃ OH		196.7	S — 0.87 _{CH₃OH}
	C ₂ H ₅ OH		196.3	S — 1.27 _{C₂H₅OH}
(COOH) ₂ ·2H ₂ O	c		340.2	S — 8.44 ²⁰ ₃₀₀
C ₂ H ₃ O ₂ ⁻	∞	acetate ion	117.946	
C ₂ H ₃ O ₂ ⁻	aq.	glycollate ion	156.0	
CH ₃ CHO	g	acetaldehyde	44.0	C 280.5
	liq.		50.6	V — 6.6 ²¹
	c			F — 0.77 ⁻¹¹⁸
	aq.		54.2	
(CH ₃ CHO) _n	liq.	paraldehyde	(54.8) _x	
	c			F — 1.11 ¹²
CH ₃ CHO	c	metalddehyde	57.0	

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
C_2H_4O	g	ethylene oxide	17.	
	liq.		23.3	V — 6.3 ¹⁸
CH_3COOH	aq.	acetic acid	24.8	S — 1.5
	liq.		117.7	C — 208.3
	c	$H^+(\infty) +$ $C_2H_3O_2^-(\infty)$ undissociated actual	120.4	F — 2.70 ¹⁷
	∞		117.946	
	∞		118.070	
	6400		118.067	
	3200		118.065	
	1600		118.062	
	800		118.059	
	400		118.055	
	200		118.045	
	100		118.024	
	50		117.983	
	25		117.91	
	8		117.70	
	4		117.59	
	2		117.54	
	1.5		117.53	
	1.0		117.55	
	0.5		117.57	
$HCOOCH_3$	g	methyl formate	84.9	C — 240.7
	liq.		91.6	V — 6.75 ²¹
$CH_2OHCOOH$	c	glycollic acid		F — 2.9 ⁻¹⁰⁰
	aq.		159.0	C — 166.6
$(OH)_2CHCOOH$	c	glyoxylic acid	156.2	S — 2.76 ^{10, 100}
	aq.		200.4	C — 125.2
$C_2H_3O^-$	C_2H_3OH	$(C_2H_3OH = H^+ +$ $C_2H_3O^-)$	197.9	S — 2.51
C_2H_5OH	g	ethyl alcohol		I — 2.8
	liq.		56.95	C — 337.06
	c		67.14	V — 10.19
	200		69.815	F — 1.15 ⁻¹¹⁴
	100		69.70	
	50		69.662	
	25		69.54	
	10.2		69.10	
	5.94		68.57	
	3.84		68.11	
	1.70		67.55	
	0.64		67.28	
	0.28		67.21	

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹	
(CH ₃) ₂ O	g	dimethyl ether	46.4	C	347.6
	liq.			V	— 4.45 ⁻²⁵
	aq.		54.7		
(CH ₂ OH) ₂	g	ethylene glycol	98.	V	— 13.2 ¹⁹⁷
	liq.		112.1	C	281.9
	aq.		113.8		
CF ₄	g	monofluoroethanol	163.		
CH ₃ FCHEOH	g		97.		
	liq.		111.		
CHF ₂ CH ₂ OH	liq.	difluoroethanol	162.9		
CH ₃ FCOOH	c	monofluoroacetic acid	162.2		
CHF ₂ COOH	liq.	difluoroacetic acid	205.6		
CCl ₄	g	carbon tetra- chloride	25.9		
	liq.		33.8	V	— 7.27 ⁷⁷
	c	I		F	— 0.67 ⁻²⁴
	c	II		T	— 1.10 ⁻⁴² ₋₁
C ₂ Cl ₄	g	tetrachloroethylene	— 6.		
	liq.		3.	V	— 8.27 ¹²⁰
C ₂ Cl ₆	g	hexachloroethane	37.	V _s	— 17.
	c		54.		
CBr ₄	g	carbon tetra- bromide	— 12.		
COCl ₂	g	phosgene	53.5		
	liq.		59.3	V	— 5.90
CCl ₃ COO ⁻	aq.	trichloroacetate ion	133.2		
CCl ₃ COCl	liq.	trichloroacetyl- chloride	79.0		
			20.1		
CH ₃ Cl	g	methyl chloride		V	— 5.17 ⁻²⁴
	liq.				
CH ₂ Cl ₂	g	methylene chloride	21.7		
	liq.		28.6	V	— 6.69 ⁴⁰
CHCl ₃	g	chloroform	23.6		
	liq.		31.2	V	— 7.04 ⁶¹
	c			F	— 2.1
	aq.		33.4	S	— 2.2
CH ₂ CHCl	g	vinyl chloride	— 9.		
	liq.		— 4.1	V	— 4.9
C ₂ H ₅ Cl	g	ethyl chloride	25.7		
	liq.		31.6	V	— 5.95 ¹²
CH ₂ ClCH ₂ Cl	g	ethylene chloride	29.3		
	liq.		37.6	V	— 7.75 ⁸⁴
CH ₃ CHCl ₂	g	ethylidene chloride	29.3		
	liq.		36.4	V	— 6.65 ⁶⁷

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CHCl ₂ CHCl ₂	g	symmetrical tetra- chloroethane	33.	
	liq.			V — 9.9 ¹⁴⁵
CCl ₃ CHCl ₂	g	pentachloroethane	35.	
	liq.		45.	V — 9.9
CH ₃ COCi	g	acetylchloride	60.9	
	liq.		66.8	
CH ₃ ClCHO	liq.	chloroacetaldehyde	62.3	
(CH ₂ ClCHO) _x	c	polymer	(66.5) _x	
CH ₃ ClCOO ⁻	aq.	monochloroacetate ion	122.1	
CH ₃ ClCOOH	g	monochloroacetic acid	107.4	V — 13.0 ⁶¹
	liq.		120.4	F — 4.63 ⁶¹
	c	α (m.p. 61°)	125.	
	c	β (m.p. 56°)	124.9	F — 4.45 ⁶⁶
	c	γ (m.p. 51°)	124.2	F — 3.79 ⁶¹
	200		121.6	S — 3.35
CH ₃ ClCH ₂ OH	liq.	monochloroethanol	75.0	
	aq.		76.3	
CH ₃ ClCOCI	liq.	chloroacetyl chloride	68.4	
CHCl ₂ COOH	g	dichloroacetic acid	114.	
	liq.		125.	S — 2.58 ¹⁵ ₄₀₀
	c		126.8	F — 1.83 ¹⁴
	aq.		127.6	
CCl ₃ CHO	g	chloral	45.5	V — 8.0
	liq.		53.5	S — 11.9
	aq.		65.4	
(CCl ₃ CHO) _x	c	polymer of chloral	(61.0) _x	
CCl ₃ COOH	liq.	trichloroacetic acid	130.	F — 1.41 ¹⁹
	c		131.4	S — 2.70 ¹⁵ ₄₀₀
	aq.		134.1	
CCl ₃ CH(OH) ₂	g	chloral hydrate	104.	
	liq.		128.7	
	c	I	131.6	T — 2.4 ₁₁
	c	II	134.2	S — 0.4
COBr ₂	g	carbonyl bromide	22.3	D — 3.14
CH ₃ Br	g	methyl bromide	8.5	
CH ₂ Br ₂	g	methylen bromide	1.	
CHBr ₃	g	bromoform	— 6.	
C ₂ H ₅ Br	g	ethyl bromide	15.5	
	liq.		22.3	V — 6.6 ³⁸
CH ₂ BrCH ₂ Br	g	ethylene bromide	10.6	
	liq.		19.7	V — 9.1

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹	
CBr ₃ CH(OH) ₂	c	bromal hydrate, I	105.	<i>S</i>	12.1 _{KOH(aq.)}
	c	II	101.0	<i>S</i>	16.1 _{KOH(aq.)}
	aq.		106.9		
C ₂ H ₅ Br ₂	liq.	ethyl perbromide	24.8		
CH ₃ OH·HBr	c			<i>F</i>	— 0.6 ⁻⁸³
	c	-CH ₃ OH(c) + HBr(g)		<i>D</i>	— 13.5 ⁻⁸³
CH ₃ BrCOOH	c	monobromoacetic acid		<i>S</i>	— 3.06 ₄₀₀
CHBr ₂ COOH	c	dibromoacetic acid		<i>S</i>	— 0.85 ₄₀₀
CBr ₃ COOH	c	tribromoacetic acid		<i>S</i>	— 0.48 ₄₀₀
CH ₃ COBr	liq.	acetyl bromide	54.9		
C ₂ I ₄	c	tetraiodoethylene	73.		
CH ₃ I	g	methyl iodide	4.5		
	liq.		2.1	<i>V</i>	— 6.5 ⁴²
CH ₂ I ₂	g	methylene iodide	25.	<i>V</i>	— 10.4
	liq.		15.		
CHI ₃	g	iodoform	44.		
	c		33.		
C ₂ H ₅ I	g	ethyl iodide	1.0		
	liq.		8.4	<i>V</i>	— 7.1 ⁷²
CH ₂ ICH ₂ I	g	ethylene iodide	16.		
	c		0.		
CH ₃ COI	liq.	acetyl iodide	41.5		
CH ₃ BrCH ₂ I	c	bromoiodoethane	11.4		
CS	g	carbon monosulfide	20.		
(CS) _n	c	polymer of CS	(- 13.) _x		
CS ₂	g	carbon bisulfide	22.		
	liq.		15.4	<i>V</i>	— 6.35 ⁴⁶
	c			<i>F</i>	— 0.66 ⁻¹¹⁶
COS	g	carbonyl sulfide	35.		
	liq.			<i>V</i>	— 4.6 ⁻⁷⁰
CH ₃ SH	g	methyl mercaptan	3.6		
	liq.		9.6	<i>V</i>	— 6.0 ¹⁴
(CH ₃) ₂ S	g	dimethyl sulfide	8.0		
	liq.		16.3	<i>V</i>	— 8.2 ³⁶
C ₂ H ₅ SH	g	ethyl mercaptan	10.		
	liq.		16.9	<i>V</i>	— 6.75 ⁴⁰
C ₂ H ₅ SO ₄ ⁻	aq.	ethylsulfate ion	207.7		
C ₂ H ₅ HSO ₄	aq.	ethylsulfuric acid	208.2		
CN	g			<i>D</i> [*]	— 160.
CN ⁺	g	² Π		<i>E</i> [*]	— 31.14
	g	² Σ ⁺		<i>E</i> [*]	— 73.44
CN ⁻	g		52.		
	aq.	cyanide ion	34.9		

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CN ₄	c	carbon perazuride	— 92.6	<i>C</i> 186.1
C ₂ N ₂	g	cyanogen	— 71.	<i>C</i> 260.
	liq.			<i>V</i> — 5.9 ⁻²⁰
	aq.		— 64.	<i>S</i> 7.
(CN ₄) _x	c	polymer of CN ₄	(— 80.2) _x	
CNO ⁻	aq.	cyanate ion	34.5	
HCN	g	hydrocyanic acid	— 30.7	
	liq.		— 24.0	<i>V</i> — 6.67 ²⁸
	c			<i>F</i> — 1.72 ⁻¹⁴
	1		— 25.4	
	4		— 24.3	
	100		— 23.9	
CH ₃ NH ₂	g	methylamine	7.3	<i>C</i> 259.7
	liq.			<i>V</i> — 6.40 ⁻⁷
	300		18.00	<i>S_x</i> 10.70 ²⁵
	500		18.05	
	1000		18.17	
CH ₃ NH ₃ ⁺	aq.	methyl ammonium ion	31.2	
NH ₂ CN	liq.	cyanamide		<i>F</i> — 2.1 ⁴⁴
	c		— 8.8	<i>C</i> 171.6
	aq.		— 12.4	<i>S₀</i> — 3.6 ¹⁵ ₁₀₀₀
NH ₄ CN	c	ammonium cyanide	1.1	<i>S</i> — 4.4 ₄₀₀
	aq.		— 3.3	
(NH ₂) ₂ CNH	c	guanidine	31.1	<i>S</i> 1.2
	aq.		32.3	<i>N</i> 14.1
(NH ₂) ₂ CNH·H ⁺	aq.	guanidine ion	32.1	
CH ₃ CN	g	acetonitrile	— 19.4	<i>C</i> 310.9
	liq.		— 11.8	<i>V</i> — 7.0 ⁸⁰
CH ₃ NC	g	methyl isocyanide	— 34.3	
	liq.		— 27.3	
(CH ₃) ₂ NH	g	dimethylamine	8.2	<i>C</i> 420.
	liq.		14.7	<i>V</i> — 6.5 ⁸
	aq.		20.9	
C ₂ H ₅ NH ₂	g	ethylamine	13.0	<i>C</i> 415.2
	liq.		19.6	<i>V</i> — 6.6 ¹⁵
	aq.		25.94	<i>S</i> _{liq.} 6.34
(CH ₃) ₂ NH·H ⁺	aq.	dimethyl aminium ion	32.8	
C ₂ H ₅ NH ₂ ·H ⁺	aq.	ethyl aminium ion	39.15	
NH ₂ CH ₂ CH ₂ NH ₂	aq.	ethylene diamine	14.5	
(CH ₂ NH ₂ ·H) ₂ ⁺⁺	aq.	ethylene diaminium ion	— 37.7	
NH ₂ C(:NH)NHCN	c	dicyandiamide	— 3.1	<i>C</i> 328.7
	aq.		— 8.9	<i>S</i> — 5.77

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HCNO	aq.	cyanic acid	36.5	
CH ₂ NO ₂ ⁻	aq.	nitromethane ion	20.2	
HCONH ₂	liq.	formamide	62.0	C 134.9
	aq.		57.8	
CH ₂ NO ₂	g	nitromethane	18.6	V — 8.25 ⁹⁹
	liq.		27.6	C — 169.4
	aq.		27.0	S — 0.6
HCOONH ₄	c	ammonium formate	133.2	S — 2.94 ¹⁰ ₁₄₀
	aq.		131.3	N — 11.9 ¹⁰ ₂₀₀
NH ₄ HCO ₃	c	ammonium bicarbonate	203.0	S — 6.8 ₁₂₀₀
	400		196.19	
	200		196.29	
	100		196.4	
	40		196.58	
NH ₄ CNO	c	ammonium cyanate	73.5	S — 6.23
	aq.		67.3	
(NH ₂) ₂ CO	c	urea	78.5	S — 3.35
	aq.		75.15	
NH ₂ COONH ₄	c	ammonium carbamate	159.0	S — 3.80 ¹⁵
	aq.		155.2	
(NH ₄) ₂ CO ₃	aq.	ammonium carbonate	223.6	
(NH ₂) ₂ CO·HNO ₃	c	urea nitrate	135.1	S — 10.7
	aq.		124.4	
(NH ₂) ₂ C(:NH)·HNO ₃	c	guanidine nitrate	92.1	C — 207.5
	aq.		82.0	S — 10.15
CONH ₂ COO ⁻	aq.	oxamate ion	153.6	
CH ₃ NCO	liq.	methyl isocyanate	22.	C — 269.4
HOCH ₂ CN	liq.	glycollic nitrile	34.8	C — 256.7
CONH ₂ COOH	c	oxamic acid	161.4	C — 130.1
	aq.		154.0	S — 7.4 ¹¹
CH ₃ CHNO ₂ ⁻	aq.	nitroethane ion	27.	
NH ₂ CH ₂ COO ⁻	aq.	aminoacetate, or glycinate, ion	112.0	
CH ₃ CONH ₂	c	acetamide	77.98	
	liq.			F — 0.43 ⁸¹
	200		75.93	S — 2.05 ¹⁷ ₂₀₀
CH ₃ CHNOH	c	acetaldoxime	19.2	C — 340.6
C ₂ H ₅ ONO	g	ethyl nitrite	25.9	C — 333.9
C ₂ H ₅ NO ₂	g	nitroethane	23.	
	liq.		33.	V — 9.9 ²¹
	aq.		32.	

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
NH ₂ CH ₂ COOH	c	aminoacetic acid, glycine	126.4	<i>C</i> 233.4
	aq.		122.8	<i>S</i> — 3.58
C ₂ H ₅ ONO ₂	g	ethyl nitrate	33.4	
	liq.		41.5	
COOHCOONH ₄	aq.	ammonium bioxa- late	226.7	<i>N</i> 12.5
NH ₂ CH ₂ COOH·H ⁺	aq.	glycinium ion	123.6	
CH ₃ COONH ₄	c	ammonium acetate	149.0	<i>S</i> 0.25 ²⁴ ₁₀₀
	∞	NH ₄ ⁺ (∞) + C ₂ H ₃ O ₂ ⁻ (∞)	149.40	
	400		149.31	
	200		149.27	
	100		149.18	
	50		149.05	
	25		148.85	
	10		148.45	
	5		148.10	
	2		147.55	
CH ₂ OHCOONH ₄	c	ammonium glycol- late	190.9	<i>S</i> — 3.2
	aq.		187.7	<i>N</i> 12.2
CH ₃ NH ₂ HCO ₂	aq.	methylamine bi- carbonate	196.0	<i>N</i> 9.0
(OH) ₂ CHCOONH ₄	aq.	ammonium gly- oxylate	229.1	<i>N</i> 12.2
(CONH ₂) ₂	c	oxamide	122.4	<i>C</i> 203.2
NH ₂ CONHCHO	liq.	formyl urea	118.6	<i>C</i> 207.0
	aq.		111.3	<i>S</i> — 7.3
(CH ₃) ₂ NNO	liq.	dimethyl nitroso- amine	0.	<i>C</i> 394.
C ₂ H ₅ NHNO ₂	liq.	ethyl nitroamine	22.	<i>C</i> 372.
(CH ₂ NH ₂) ₂ ·H ₂ O	c	ethylene diamine monohydrate	77.8	<i>C</i> 453.
			267.2	<i>S</i> — 8.0
(COONH ₄) ₂	c	ammonium oxalate	259.2	
(COONH ₄) ₂ ·H ₂ O	aq.			
	c	ammonium oxalate monohydrate	339.1	<i>S</i> — 11.5
(CH ₂ NH ₂ ·HNO ₃) ₂	aq.	ethylene diamin- ium nitrate	— 138.7	
CHF ₂ CH ₂ NH ₂	liq.	difluoroethylamine	116.7	
CH ₃ FCONH ₂	c	monofluoroacet- amide	117.1	
CHF ₂ CH ₂ NHNO ₂	c	difluoroethylnitro- amine	118.	

Carbon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CNCl	g	chlorocyanogen	— 36.5	V — 8.3
	liq.		— 28.2	
CH ₃ NH ₂ ·HCl	aq.	methylamine hydrochloride	70.8	N 13.0
(CH ₃) ₂ NH·HCl	aq.	dimethylamine hydrochloride	72.0	N 11.81 ₄₀₀
C ₂ H ₅ NH ₂ ·HCl	c	ethylamine hydrochloride	81.1	S — 2.23
	aq.		78.8	N 13.44 ₄₀₀
(CH ₂ NH ₂ ·HCl) ₂	c	ethylene diaminium chloride	123.4	S — 6.65
	aq.		116.7	
CH ₃ ClCONH ₂	c	monochloroacetamide	88.5	
	aq.		77.8	
NH ₂ CH ₂ COOH·HCl	aq.	glycine hydrochloride	163.2	N 0.97
CH ₃ ClCOONH ₄	aq.	ammonium monochloroacetate	153.8	N 12.9
CHCl ₂ CONH ₂	aq.	dichloroacetamide	82.7	
CCl ₃ CONH ₂	c	trichloroacetamide	107.4	C 165.2
	aq.		87.2	
CCl ₃ COONH ₄	aq.	ammonium trichloroacetate	165.1	N 13.1
CNI	c	iodocyanogen	— 39.1	S — 2.8
	aq.		— 41.9	
CNS-	aq.	thiocyanate ion	— 18.9	
HCNS	aq.	thiocyanic acid	— 19.1	
(NH ₂) ₂ CS	c	thiourea	31.5	C 270.6
	aq.		26.2	S — 5.33 _{10,100}
NH ₄ CNS	c	ammonium thiocyanate	18.2	S — 5.7
	aq.		12.5	
CH ₃ CNS	g	methyl thiocyanate	— 35.	
	liq.		— 23.	
CH ₃ NCS	g	methyl isothiocyanate	— 28.	
	c		— 10.	
(NH ₂) ₂ CS·HNO ₃	c	thiourea nitrate	83.8	S — 8.5
	aq.		75.3	

Silicon

Atomic number 14

Standard state Si (c)

Atomic weight 28.06

Formula	State	Description	Q_f , kcal, mole ⁻¹	Q , kcal. mole ⁻¹
Si	g	3s ² 3p ² (³ P ₀)	— 85.	
	c		0.000	
	amorp.		— 1.0	
Si*	g	3s ² 3p ² (³ P ₁)	— 85.22	E^* — 0.22
	g	(³ P ₂)	— 85.64	E^* — 0.64
	g	(¹ D ₂)	— 102.93	E^* — 17.93
	g	(¹ S ₀)	— 128.82	E^* — 43.82
Si+	g	3s ² 3p (² P _{1/2})	— 273.7	I^* — 187.22
Si+ *	g	(² P _{3/2})	— 274.5	E^* — 0.82
	g	(² D _{3/2})	— 431.1	E^* — 157.44
	g	(² D _{5/2})	— 432.1	E^* — 157.48
Si++	g	3s ² (¹ S ₀)	— 650.4	I^* — 375.26
	g	(³ P ₂)	— 742.0	E^* — 111.59
	g	(³ P ₁)	— 742.4	E^* — 111.96
	g	(³ P ₀)	— 743.1	E^* — 112.71
Si+++	g	3s (² S _{1/2})	— 1421.0	I^* — 769.12
Si++++	g	2s ² 2p ⁶ (¹ S ₀)	— 2459.1	I^* — 1036.6
Si+++++	g	2s ² 2p ⁵ (² P _{3/2})	— 6355.	I^* — 3895.
SiO ₂	g		120.	V — 79 ¹⁹⁰⁰
	liq.			F — 1.84 ¹⁸³⁰
	gls.		201.0	
	c	β cristobalite 1600° form		T 0.15 ²⁷⁰ → α crist. 1600°
	c	β cristobalite 1100° form		T 0.06 ²³⁰ → α crist. 1100°
	c	α cristobalite 1600° form	202.61	
	c	α cristobalite 1100° form	202.45	
	c	β tridymite		T 0.02 α tridymite
	c	β quartz		T 0.18 ⁵⁷³ → α quartz
	c	α quartz	203.34	
	colloid	in water	199.1	
SiH ₄	g		8.7	D — 8.7
	liq.			V — 3.03 ⁻¹¹²
Si ₂ H ₆	g			V — 5.11 ⁻¹⁵
Si ₄ H ₈	liq.			V — 7.1 ⁶³
Si ₄ H ₁₀	liq.			V — 8.9 ¹⁰⁹
H ₂ SiO ₃	c	ppt.	267.8	D — 10.9
H ₄ SiO ₄	c	ppt.	330.1	D — 8.7
	colloid	in water	335.9	
H ₂ Si ₂ O ₅	c	ppt.	458.7	D — 12.7
H ₆ Si ₂ O ₇	c	ppt.	603.5	D — 10.1
SiF ₄	g		360.1	S 33.9 _{2HF(aq.)}
	liq.			V — 4.46 ⁻⁹⁰
	c			F — 1.7 ⁻⁹⁵
SiF ₆ ---	aq.		544.0	

Silicon

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HSiF ₆ ⁻	aq.		544.5	
H ₂ SiF ₆	aq.		545.0	
SiCl ₄	g		142.5	$V - 7.19^{87}$
	liq.		150.1	
	c			$F - 1.85^{-70}$
Si ₂ Cl ₆	liq.			$V - 11.0^{139}$
Si ₃ Cl ₈	liq.			$V - 12.1^{213}$
(SiCl ₃) ₂ O	liq.			$V - 9.4^{137}$
SiClH ₃	g			$V - 5.1^{-10}$
SiCl ₂ H ₂	g			$V - 6.1^{12}$
SiBr ₄	liq.		93.6	$S - 83.0_{7000}$
SiBrH ₃	g			$V - 5.85^2$
SiBr ₂ H ₂	g			$V - 7.4^{68}$
SiI ₄	c		29.8	$S - 85.7$
SiS ₂	c	yellow	30.9	
	c	white	34.1	
Si ₃ N ₄	c		157.0	
(NH ₄) ₂ SiF ₆	c		621.6	$S - 8.4^7_{1200}$
	aq.		613.2	
SiC	c		28.	
(C ₂ H ₅ O) ₄ Si	liq.	ethylorthosilicate	320.	$S - 21.6$
(CH ₃ O) ₄ Si	liq.	methyl silicate		$V - 7.08^{121}$

Germanium

Atomic number 32

Standard state Ge (c)

Atomic weight 72.60

Ge	g	4s ² 4p ² (³ P ₀)	- 85.	
	c		0.000	
Ge*	g	4s ² 4p ² (³ P ₁)	- 86.58	$E^* - 1.58$
	g	(³ P ₂)	- 89.01	$E^* - 4.01$
	g	(¹ D ₂)	- 105.29	$E^* - 20.29$
	g	(¹ S ₀)	- 131.59	$E^* - 46.59$
Ge ⁺	g	4s ² 4p (² P _{1/2})	- 275.9	$I^* - 189.47$
Ge ⁺ *	g		- 280.9	$E^* - 5.03$
Ge ⁺⁺	g	4s ² (¹ S ₀)	- 543.6	$I^* - 366.20$
Ge ⁺⁺⁺	g	4s (² S _{1/2})	- 1330.8	$I^* - 785.81$
Ge ⁺⁺⁺⁺	g	3d ¹⁰ (¹ S ₀)	- 2377.0	$I^* - 1044.75$
GeO ₂	colloid	in water	230.	
Ge ₂ H ₆	liq.			$V - 6.3^{29}$
Ge ₃ H ₈	liq.			$V - 7.6^{111}$
GeCl ₄	g		216.	$V - 9.2^{86}$
	liq.		226.	

Tin

Atomic number 50 Standard state Sn (c, II, tetragonal) Atomic weight 118.70

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Sn	g	5p ² (³ P ₀)	— 78.	
	liq.			F — 1.69 ²³²
	c	I, rhombic		T — .002 ¹⁶¹ —II
	c	II, tetragonal	0.000	
Sn*	c	III, "gray" cubic	— 0.6	T — 0.6—II
	g	5p ² (³ P ₁)	— 82.82	E° — 4.82
	g	(³ P ₂)	— 87.76	E° — 9.76
	g	(¹ D ₂)	— 102.52	E° — 24.52
Sn ⁺	g	(¹ S ₀)	— 126.86	E° — 48.86
	g	5p (² P _{1/2})	— 258.0	I° — 168.51
	g	(² P _{3/2})	— 270.1	E° — 12.11
	g	5s ² (¹ S ₀)	— 594.5	I° — 335.1
Sn ⁺ *	g	5s (² S _{1/2})	— 1299.5	I° — 704.0
Sn ⁺⁺	g	4d ¹⁰ (¹ S ₀)	— 2237.0	I° — 936.
Sn ⁺⁺⁺	g	4d ⁹ (² D)	— 3580.	I° — 1340.
Sn ⁺⁺⁺⁺	g		67.7	C — 70.4
SnO	c	I		T — 0.30 ³⁴⁰ —II
SnO ₂	c	II		T — 0.45 ⁴³⁰ —III
	c	III	138.1	
	liq.			V — 4.55 ⁻¹⁶⁰
SnH ₄	c	ppt.	136.1	
Sn(OH) ₂	c	ppt.	268.9	
Sn(OH) ₄	c		469.8	
SnF ₆ --	aq.		470.4	
H ₂ SnF ₆	aq.			V — 21.1 ⁴²³
SnCl ₂	g		81.1	
	c		81.5	
	HCl(200)		223.5	S — 5.29
SnCl ₂ ·2H ₂ O	c		118.4	V — 8.0 ¹¹⁶
SnCl ₄	g		127.4	S — 29.92 ³⁰ ₂₅₀
	liq.			F — 2.20 ⁻³³
	c		157.3	
	HCl(200)		146.8	
SnOCl ₂	aq.		61.4	
SnBr ₂	c		59.8	
	aq.		91.8	F — 3.00 ²⁷
	liq.		94.8	S — 15.5 ¹⁵ ₁₀₀₀
SnBr ₄	c		110.3	
	aq.		653.7	F — 10.20 ¹⁵
	liq.		663.9	S — 6.64 ¹⁵ ₁₂₀₀
SnBr ₄ ·8H ₂ O	c		38.9	S — 5.8
SnI ₂	c		33.1	
	aq.		22.7	
SnS	c			

Tin

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
$\text{Sn}(\text{SO}_4)_2$	c		391.1	S 91.1 _{KOH(aq.)}
$\text{SnCl}_4 \cdot 2\text{H}_2\text{S}$	c			D — 6.2 ⁻⁵⁸
$\text{SnCl}_4 \cdot 4\text{H}_2\text{S}$	c			D — 6.2 ⁻⁸¹
$\text{SnCl}_2 \cdot 2\frac{1}{2}\text{NH}_3$	c		146.7	S 14.0 _{HCl(aq.)}
$\text{SnCl}_2 \cdot 4\text{NH}_3$	c		162.1	D — 9.3
$\text{SnCl}_2 \cdot 9\text{NH}_3$	c		254.9	D — 7.6
$\text{SnBr}_2 \cdot 2\text{NH}_3$	c		116.2	S 7.3 _{HCl(aq.)}
$\text{SnBr}_2 \cdot 3\text{NH}_3$	c		139.7	S 14.8 _{HCl(aq.)}
$\text{SnBr}_2 \cdot 5\text{NH}_3$	c		181.2	D — 9.8
$\text{SnBr}_2 \cdot 9\text{NH}_3$	c		255.3	D — 7.55
$\text{SnI}_2 \cdot \text{NH}_3$	c		65.8	D — 16.0
$\text{SnI}_2 \cdot 2\text{NH}_3$	c		90.1	D — 13.3
$\text{SnI}_2 \cdot 3\text{NH}_3$	c		112.9	D — 11.9
$\text{SnI}_2 \cdot 5\text{NH}_3$	c		155.2	D — 10.2
$\text{SnI}_2 \cdot 9\text{NH}_3$	c		230.6	D — 7.9
$\text{SnCl}_4 \cdot 1\frac{1}{2}\text{PH}_3$	c		148.5	
SnBi	c		0.37	
SnBi_2	c		— 0.17	
SnBi_3	c		— 0.19	
Sn_2Bi	c		— 0.12	
Sn_4Bi	c		— 0.78	

Lead

Atomic number 82

Standard state Pb (c)†

Atomic weight 207.22

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Pb	g	6p ² (³ P ₀)	47.5	$V - 45.1620$
	liq.			$F - 1.30^{327}$
	c	fine crystals, non-radioactive	0.000	
Pb*	c	"stick"	- 0.07	
	g	6p ² (³ P ₁)	- 69.76	$E^* - 22.26$
	g	³ P ₂	- 78.82	$E^* - 30.32$
	g	¹ D ₂	- 108.59	$E^* - 61.09$
	g	¹ S ₀	- 147.96	$E^* - 100.46$
Pb ⁺	g	6p (² P _{1/2})	- 219.25	$I^* - 170.30$
Pb ⁺ *	g	(² P _{3/2})	- 259.30	$E^* - 40.05$
Pb ⁺⁺	g	6s ² (¹ S ₀)	- 565.89	$I^* - 345.19$
	aq.		0.2	
Pb ⁺⁺⁺	g	6s (² S _{1/2})	- 1304.0	$I^* - 736.68$
Pb ⁺⁺⁺⁺	g	4d ¹⁰ (¹ S ₀)	- 2318.7	$I^* - 1013.3$
PbO	c	red	52.46	
	c	yellow	52.06	
PbO ₂	c		65.0	
Pb ₂ O	c		51.3	
Pb ₃ O ₄	c		172.4	
Pb(OH) ₂	c	ppt.	123.0	
PbF ₂	g		100.	$V - 39.4^{1200}$
	c		159.5	
	g		49.4	$V - 28.5^{816}$
PbCl ₂	liq.			$F - 5.6^{800}$
	c		85.71	$S - 3.44$
	aq.		82.3	
PbCl ₂ ·PbO	c		142.7	$S \quad 18.1_{HCl(aq.)}$
PbCl ₂ ·2PbO	c		195.9	$S \quad 40.0_{HCl(aq.)}$
PbCl ₂ ·3PbO	c		247.9	$S \quad 63.2_{HCl(aq.)}$
PbBr ₂	g		5.	$V - 28.1^{816}$
	c		66.27	
	aq.		56.2	$S \quad 10.04$
PbBr ₂ ·PbO	c		119.8	$S \quad 24.0_{HBr(aq.)}$
PbBr ₂ ·2PbO	c		171.4	$S \quad 50._{HBr(aq.)}$
PbBr ₂ ·3PbO	c		223.4	$S \quad 75.6_{HBr(aq.)}$
PbI ₂	g		- 10.	$V - 27.7^{800}$
	liq.			$F - 5.3^{375}$
	c		41.77	
PbI ₂ ·HI·5H ₂ O	c		400.9	$S - 3.8^{11200}$
PbS	c		22.3	
PbSO ₄	c	II	218.5	

†Non-radioactive.

Lead

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
PbSO ₄	c	I		T 4.06 ⁸⁶⁰ → II
PbS ₂ O ₃	c		151.1	
PbS ₂ O ₆	aq.		280.4	
PbS ₂ O ₆ ·4H ₂ O	c		562.4	S — 8.54 ₄₀₀
PbS ₃ O ₆	c		284.0	S — 5.0
	aq.		279.	
PbSO ₄ ·PbO	c		280.	
PbSO ₄ ·2PbO	c		339.	
PbSO ₄ ·3PbO	c		398.	
PbSO ₄ ·2HCl	c		276.	D — 6.8
PbSe	c		20.	
PbSeO ₄	c		148.6	
	aq.		146.6	
PbTe	c		6.0	
PbN ₆	c		103.0	
Pb(NO ₃) ₂	c		106.89	S — 7.6 ₄₀₀
	400		99.28	
	200		99.80	
	100		100.56	
	40		101.78	
Pb(NO ₃) ₂ ·PbO	c		167.6	
PbCl ₂ ·NH ₃	c		109.0	D — 13.3
PbCl ₂ ·1½NH ₃	c		121.0	D — 11.7
PbCl ₂ ·2NH ₃	c		132.0	D — 11.0
PbCl ₂ ·3½NH ₃	c		157.4	D — 9.4
PbCl ₂ ·8NH ₃	c		248.4	D — 8.2
2PbCl ₂ ·NH ₄ Cl	c		246.66	
PbBr ₂ ·NH ₃	c		92.8	D — 15.6
PbBr ₂ ·2NH ₃	c		115.2	D — 11.4
PbBr ₂ ·3NH ₃	c		135.6	D — 9.5
PbBr ₂ ·5½NH ₃	c		185.6	D — 9.0
PbBr ₂ ·8NH ₃	c		207.0	D — 8.2
PbI ₂ ·½NH ₃	c		54.5	D — 14.4
PbI ₂ ·NH ₃	c		66.6	D — 13.2
PbI ₂ ·2NH ₃	c		88.8	D — 11.3
PbI ₂ ·5NH ₃	c		150.8	D — 9.7
PbI ₂ ·8NH ₃	c		207.0	D — 7.8
3PbI ₂ ·4NH ₄ I	c		315.1	S — 10.25
3PbI ₂ ·4NH ₄ I·6H ₂ O	c		598.1	S — 19.76
PbSO ₄ ·(NH ₄) ₂ SO ₄	c		502.3	S — 3.74
PbHPO ₃	c		231.7	
3PbI ₂ ·PI ₃	c		131.8	S 27.6
3PbI ₂ ·PI ₃ ·12H ₂ O	c		977.3	S 2.5
3PbI ₂ ·AsI ₃	c		111.0	S 12.5
3PbI ₂ ·AsI ₃ ·12H ₂ O	c		952.2	S — 8.2

Lead

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
3PbI ₂ ·SbI ₃	c		127.0	<i>S</i> 20.6
3PbI ₂ ·SbI ₃ ·12H ₂ O	c		976.5	<i>S</i> — 8.5
3PbI ₂ ·BiI ₃	c		136.0	<i>S</i> 16.6
3PbI ₂ ·BiI ₃ ·12H ₂ O	c		990.2	<i>S</i> — 17.2
PbCO ₃	c		168.0	
PbC ₂ O ₄	c	lead oxalate	206.2	
PbCO ₃ ·PbO	c		222.6	
PbCO ₃ ·2PbO	c		274.8	
Pb(CHO ₂) ₂	c	lead formate	206.9	<i>S</i> — 6.9 ¹⁰
	aq.		200.0	
Pb(C ₂ H ₃ O ₂) ₂	c	lead acetate	234.3	<i>S</i> 1.4 ¹¹ ₂₂₀
	400		235.7	
Pb(C ₂ H ₃ O ₂) ₂ ·3H ₂ O	c		446.7	<i>S</i> — 6.14
Pb(C ₂ H ₃ O ₂) ₂	c	lead glycollate	317.3	<i>S</i> — 5.74
	aq.		311.5	
PbO·Pb(C ₂ H ₃ O ₂) ₂	c	basic lead acetate	292.9	
Pb(CN) ₂ ·2PbO·H ₂ O	c		125.	<i>S</i> 36.8 _{HNO₃ (aq.)}
Pb(SCN) ₂	c	ppt.	— 30.7	
PbI ₂ ·SnI ₂	c		68.6	<i>S</i> 12.7
PbI ₂ ·SnI ₂ ·8H ₂ O	c		635.8	<i>S</i> — 7.5

Gallium

Atomic number 31

Standard state Ga (c)

Atomic weight 69.72

Ga	g	4p (² P _{1/2})	— 52.	
	c		0.000	
Ga*	g	4p (² P _{1/2})	— 54.35	<i>E</i> * — 2.35
	g	² S _{1/2}	— 122.57	<i>E</i> * — 70.57
Ga ⁺	g	4s ² (¹ S ₀)	— 194.0	<i>I</i> * — 140.57
Ga ⁺⁺	g	4s (² S _{1/2})	— 666.5	<i>I</i> * — 471.0
Ga ⁺⁺⁺	g	3d ¹⁰ (¹ S ₀)	— 1363.4	<i>I</i> * — 705.4
	aq.		34.	
Ga ⁺⁺⁺⁺	g	3d ⁹ (² D)	— 2837.	<i>I</i> * — 1472.
Ga ₂ O ₃	c		256.	
GaCl ₃	aq.		143.	
	HCl(9)		146.	

Indium

Atomic number 49

Standard state In (c)

Atomic weight 114.76

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
In	g	5p (² P _{1/2})	— 52.	
	c		0.000	
In*	g	5p (² P _{3/2})	— 58.30	E^* — 6.30
	g	6s (² S _{1/2})	— 121.38	E^* — 69.38
In ⁺	g	5s ² (¹ S ₀)	— 186.30	I^* — 132.85
In ⁺⁺	g	5s (² S _{1/2})	— 621.1	I^* — 433.7
In ⁺⁺⁺	g	4d ¹⁰ (¹ S ₀)	— 1266.3	I^* — 643.8
	aq.		27.	
In ⁺⁺⁺⁺	g	4d ⁹ (² D _{5/2})	— 1360.	I^* — 1000.
In ₂ O ₃	c		240.	
InCl	c		44.6	
InCl ₂	c		86.8	
InCl ₃	c		128.5	S 16.9
	aq.		145.4	
InBr ₃	c		97.2	S 16.9 _{HCl (22)}
	aq.		112.7	
InI ₃	c		56.5	S 10.5 _{HCl (22)}
	aq.		67.0	
InCl ₃ ·NH ₃	c		112.0	D — 22.2
InCl ₃ ·2NH ₃	c		192.7	D — 20.3
InCl ₃ ·3NH ₃	c		223.4	D — 19.7
InCl ₃ ·5NH ₃	c		268.9	D — 11.8
InCl ₃ ·7NH ₃	c		308.0	D — 8.6
InCl ₃ ·15NH ₃	c		536.8	D — 7.65
InBr ₃ ·3NH ₃	c		190.4	S 15.5 _{HCl (22)}
InBr ₃ ·5NH ₃	c		240.0	D — 14.3
InBr ₃ ·6NH ₃	c		279.6	D — 8.8
InBr ₃ ·15NH ₃	c		432.5	D — 8.17
InI ₃ ·NH ₃	c		87.6	D — 20.1
InI ₃ ·2NH ₃	c		116.2	S 14.0 _{HCl (22)}
InI ₃ ·5NH ₃	c		197.0	S 22.7 _{HCl (22)}
InI ₃ ·7NH ₃	c		241.7	S 46.4 _{HCl (22)}
InI ₃ ·9NH ₃	c		281.1	D — 7.7
InI ₃ ·15NH ₃	c		356.2	D — 7.4

Thallium

Atomic number 81

Standard state Tl (c)

Atomic weight 204.39

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Tl	g	6p (² P _{1/2})	— 40.	
	liq.			F — 1.47
	c	I		T 0.05 ²²⁶ _{-II}
	c	II	0.000	
Tl*	g	6p (² P _{1/2})	— 62.18	E^* — 22.18
	g	7s (² S _{1/2})	— 115.38	E^* — 75.38
Tl ⁺	g	6s ² (¹ S ₀)	— 181.70	I^* — 140.24
	aq.		— 0.8	
Tl ⁺⁺	g	6s (² S _{1/2})	— 651.7	I^* — 186.7
Tl ⁺⁺⁺	g	5d ¹⁰ (¹ S ₀)	— 1338.	I^* — 684.9
	aq.		— 28.	
Tl ₂ O	c		42.3	S — 3.08
Tl ₂ O ₃	c		120.	
TlOH	c		56.95	S — 3.15
	aq.		53.8	
TlF	g			V — 25.1 ²⁹⁸
TlF	800		77.5	N 16.44 ₈₀₀
TlHF ₂	800		152.6	
TlCl	g		16.4	V — 25.2 ⁸⁰⁸
	liq.			F — 3.95 ⁴⁵⁰
	c		48.62	
	aq.		38.3	S — 10.3
TlCl*	g		— 71.8	E^* — 88.22
TlCl ₃	c		82.4	S 8.4 ₃₀₀
	aq.		90.8	
TlCl ₃ ·4H ₂ O	c		366.4	S — 2.12 ₃₀₀
TlBr	g		9.5	V — 25.2 ⁸¹⁷
	liq.			F — 3.6 ⁴⁵⁶
	c		41.5	
TlBr*	g		— 73.4	E^* — 82.9
TlBr ₃	aq.		58.1	
TlBr ₃ ·4H ₂ O	c		333.9	S — 2.25 ₃₀₀
TlBr ₂ Cl	aq.		69.0	
TlBr ₂ Cl·4H ₂ O	c		345.5	S — 2.90
TlI	g		0.7	V — 25.3 ⁸²⁴
	c		31.1	
Tl ₂ S	c		22.0	
Tl ₂ SO ₄	c		221.8	S — 7.95 ²⁰ ₃₂₀₀
	3200		213.8	
	800		213.9	
	200		214.25	

Thallium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Tl ₂ Se	c		18.	
Tl ₂ Te	c		7.	
TlN ₃	c		— 54.7	
TlNO ₃	c	I		T 0.76 ¹⁴⁵ →II
	c	II		T 0.24 ⁷⁵ →III
	c	III	58.2	S — 10.0 ₂₀₀
	aq.		48.2	
TlCl·3NH ₃	c		102.9	D — 7.1
TlBr·3NH ₃	c		95.2	D — 7.1
TlI·3NH ₃	c		84.3	D — 7.1
Tl ₂ SO ₄ ·10NH ₃	c			D — 13.3
TlC ₂ H ₃ O ₂	aq.	thallous acetate	117.0	
TlC ₂ H ₃ O	c	thallous alcoholate	56.8	
	C ₂ H ₅ OH		56.3	S — 0.53
TlCNO	c		— 25.7	D — 52.5

Zinc

Atomic number 30

Standard state Zn (c)

Atomic weight 65.38

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Zn	g	4s ² (¹ S ₀)	- 27.4	V - 24.8 ⁹¹¹
	liq.			F - 1.70 ⁴¹⁹
	c		0.000	
Zn*	g	4s4p (³ P ₁ ⁰)	- 119.38	E^* - 91.98
	g	(³ P ₁ ¹)	- 119.92	E^* - 92.52
	g	(³ P ₁ ²)	- 120.03	E^* - 93.63
	g	4p (¹ P ₁ ¹)	- 160.83	E^* - 133.43
Zn ⁺	g	4s (² S _{1/2})	- 244.54	I^* - 215.69
Zn ⁺ *	g	4p (² P _{1/2} ¹)	- 382.55	E^* - 138.01
	g	(² P _{3/2} ¹)	- 385.04	E^* - 140.50
Zn ⁺⁺	g	3d ¹⁰ (¹ S ₀)	- 658.46	I^* - 412.47
	aq.		36.3	
Zn ⁺⁺⁺	g	3d ⁹ (² D)	- 1570.	I^* - 910.
Zn ₂	g		- 48.2	D^* - 5.67
ZnO	c	unfused	83.5	
	c	fused	85.2	
ZnH	g	² Σ	- 55.4	D^* - 23.05
ZnH*	g	² Π _{1/2}	- 121.7	
	g	² Π _{3/2}	- 122.6	
	g	² Σ ₁	- 142.9	D^* - 28.9
ZnH ⁺	g	² Σ	- 223.1	D^* - 67.5
Zn(OH) ₂	c	"crystalline"	155.8	
	c	ppt.	153.5	
ZnO ₂ ·2H ₂ O	c		253.7	S 14.85 H ₂ SO ₄ (320)
Zn(OH) ₂ ·H ₂ O	c	ppt.	221.9	
ZnO· $\frac{1}{2}$ H ₂ O ₂	c		108.6	S 15.5 H ₂ SO ₄ (300)
Zn ₂ O ₃ ·2H ₂ O	c		369.7	S 48.1 H ₂ SO ₄ (300)
Zn ₂ O ₃ ·3H ₂ O	c		439.7	S 46.5 H ₂ SO ₄ (300)
ZnF ₂	aq.		192.3	
ZnCl ₂	c		99.55	S 15.72 ₄₀₀
	400		115.27	
	200		114.88	
	100		114.05	
	50		112.55	
	20		10.37	
	10		109.06	
	5		107.20	
	C ₂ H ₅ OH		109.4	S 9.8 ₃₂₀ C ₂ H ₅ O H
ZnCl ₂ ·3ZnO·5H ₂ O	c		705.4	S 61.5 HCl (aq.)
ZnCl ₂ ·4ZnO·11H ₂ O	c		1204.3	S 76.6 HCl (aq.)
ZnCl ₂ ·5ZnO·8H ₂ O	c		1083.8	S 95.6 HCl (aq.)
ZnCl ₂ ·8ZnO·10H ₂ O	c		1478.7	S 148.5 HCl (aq.)
ZnBr ₂	c		78.4	S 15.0 ₄₀₀
	400		93.4	

Zinc

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
$ZnBr_2 \cdot 4ZnO \cdot 13H_2O$	c		1320.	S 78.0 _{HBr(aq.)}
ZnI	g		— 6.	
ZnI*	g		— 91.7	E° — 85.74
ZnI ₂	c		49.8	S 11.6 ²⁸ ₆₅₀
	aq.		61.4	
$ZnI_2 \cdot 5ZnO \cdot 11H_2O$	c		940.2	S 115.6 _{HI(aq.)}
ZnS	c	zinc blend ppt.	44.	
	c		44.3	
ZnSO ₄	c		233.4	S 18.54 ₄₀₀
	400		251.95	
	200		251.94	
	100		251.92	
	50		251.87	
	20		251.63	
$ZnSO_4 \cdot H_2O$	c		310.3	S 10.0 ₄₀₀
$ZnSO_4 \cdot 6H_2O$	c		663.0	S — 0.84 ₄₀₀
$ZnSO_4 \cdot 7H_2O$	c		734.8	S — 4.28 ₄₀₀
ZnS_2O_4	aq.		198.	
ZnS_2O_5	400		317.0	
$ZnS_2O_5 \cdot 6H_2O$	c		729.5	S — 2.24 ₄₀₀
ZnSe	c		34.	
ZnTe	c		33.	
ZnN ₆	c		— 50.8	
$Zn(NO_3)_2$	400		134.7	
	200		134.87	
	50		134.86	
	20		134.81	
	15		134.57	
	10		133.66	
	3		132.	
$Zn(NO_3)_2 \cdot 3H_2O$	c		345.	F — 8.3 ⁴⁴
$Zn(NO_3)_2 \cdot 6H_2O$	c		550.9	S — 5.85 ₄₀₀
$ZnF_2 \cdot 2H_2O \cdot \frac{1}{2}NH_3$	c			
$ZnF_2 \cdot 2H_2O \cdot 3NH_3$	c			D — 11.2
$ZnCl_2 \cdot NH_3$	c		135.3	D — 25.
$ZnCl_2 \cdot NH_3 \cdot \frac{1}{2}H_2O$	c		180.8	S 13.75 _{HCl(100)}
$ZnCl_2 \cdot 2NH_3$	c		165.6	D — 19.2
$ZnCl_2 \cdot 4NH_3$	c		211.3	D — 118.
$ZnCl_2 \cdot 5NH_3 \cdot H_2O$	c		294.1	S 46.9 _{HCl(aq.)}
$ZnCl_2 \cdot 6NH_3$	c		255.3	D — 10.7
$ZnCl_2 \cdot 8NH_4Cl \cdot ZnO$	c		777.5	S 9.5 _{HCl(100)}
$ZnCl_2 \cdot 10NH_3$	c		327.3	D — 7.1
$3ZnCl_2 \cdot 6NH_4Cl \cdot H_2O$	c		831.1	S 6.5 _{HCl(100)}
$3ZnCl_2 \cdot ZnO \cdot 10NH_4Cl$	c		913.2	S 16.2 _{HCl(aq.)}
$6ZnCl_2 \cdot ZnO \cdot 12NH_3$	c		1347.4	S 95.6 _{HCl(100)}

Zinc

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
ZnBr ₂ ·NH ₃	c		122.9	<i>D</i> — 24.1
ZnBr ₂ ·2NH ₃	c		153.8	<i>D</i> — 19.2
ZnBr ₂ ·4NH ₃	c		202.8	<i>D</i> — 11.82
ZnBr ₂ ·6NH ₃	c		246.7	<i>D</i> — 11.02
ZnI ₂ ·NH ₃	c		82.4	<i>D</i> — 22.
ZnI ₂ ·2NH ₃	c		112.5	<i>D</i> — 19.4
ZnI ₂ ·4NH ₃	c		166.0	<i>D</i> — 15.4
ZnI ₂ ·6NH ₃	c		209.8	<i>D</i> — 10.9
ZnSO ₄ ·½NH ₃	c		251.4	<i>D</i> — 25.
ZnSO ₄ ·NH ₃	c		268.	<i>D</i> — 22.4
ZnSO ₄ ·2NH ₃	c		298.	<i>D</i> — 18.9
Zn(NH ₄) ₂ (SO ₄) ₂ ·2H ₂ O	c		661.7	
Zn(NH ₄) ₂ (SO ₄) ₂ ·6H ₂ O	c		954.5	<i>S</i> — 13.2
ZnSO ₄ ·3NH ₃	c		324.	<i>D</i> — 15.5
ZnSO ₄ ·4NH ₃	c		349.	<i>D</i> — 13.8
ZnSO ₄ ·5NH ₃	c		371.	<i>D</i> — 10.8
ZnCO ₃	c	zinc carbonate	193.3	
ZnC ₂ O ₄ ·2H ₂ O	c	zinc oxalate	373.2	
Zn(C ₂ H ₅) ₂	liq.	zinc ethyl	10.0	<i>S</i> 78.0
Zn(CHO ₂) ₂	c	zinc formate	231.3	<i>S</i> 4.0 ¹⁵ ₃₀₀
	250		235.3	
Zn(CHO ₂) ₂ ·2H ₂ O	c		374.4	<i>S</i> — 2.4 ¹³ ₃₀₀
Zn(C ₂ H ₃ O ₂) ₂	c	zinc acetate	261.1	<i>S</i> 9.8 ⁷²⁰
	400		270.9	
	200		270.02	
	100		268.95	
	50		267.75	
Zn(C ₂ H ₃ O ₂) ₂ ·H ₂ O	c		332.3	<i>S</i> 7.0 ²³ ₃₀₀
Zn(C ₂ H ₃ O ₂) ₂ ·H ₂ O	c		403.7	<i>S</i> 4.2 ¹⁰ ₃₀₀
Zn(C ₂ H ₃ O ₂) ₂	c	zinc glycollate	350.0	<i>S</i> — 0.6
	aq.		349.4	
Zn(C ₂ H ₃ O ₂) ₂ ·2H ₂ O	c		490.2	<i>S</i> — 4.1
Zn(CN) ₂	c	zinc cyanide	— 16.2	<i>S</i> 3.4 ¹² _{HCl(aq.)}
Zn(CN) ₄ —	aq.		— 79.4	
2Zn(CN) ₂ ·ZnO	c	basic zinc cyanide	39.9	<i>S</i> 25.6 ¹⁸ _{HCl(aq.)}
Zn(CHO ₂) ₂ ·2NH ₃	c	zinc formate ammine	279.	<i>D</i> — 13.
Zn(CHO ₂) ₂ ·2½NH ₃	c		290.	<i>D</i> — 10.6
Zn(CHO ₂) ₂ ·4NH ₃	c		322.	<i>D</i> — 10.5
Zn(CHO ₂) ₂ ·6NH ₃	c		360.	<i>D</i> — 8.3
ZnSiO ₃	c		282.6	<i>S</i> 85.5 _{HF(4.44)}
Zn ₂ SiO ₄	gls.		340.4	<i>S</i> 99.5 _{HF(4.44)}
	c		349.4	<i>S</i> 90.5 _{HF(4.44)}
2ZnI ₂ ·PbI ₂	c		141.2	<i>S</i> 23.50 ¹⁵ ₁₀₀₀

Cadmium

Atomic number 48 Standard state Cd (c, II, hexagonal) Atomic weight 112.41

Formula	State	Description	Q_f , kcal, mole ⁻¹	Q , kcal. mole ⁻¹
Cd	g	5s ² (¹ S ₀)	- 26.8	
	liq.			F - 1.50 ²²¹
	c	I		T 0.055 ^{37.5-11}
Cd*	c	II, hexagonal	0.000	
	g	5s5p (³ P ₁₀)	-112.53	E^* - 85.73
	g	(³ P ₁₁)	-114.07	E^* - 87.26
	g	(³ P ₁₂)	-117.41	E^* - 90.61
	g	(¹ P ₁₁)	-151.18	E^* - 124.38
Cd ⁺	g	5s (² S _{1/2})	-234.75	I^* - 206.50
Cd ⁺ *	g	5p (² P _{1/2})	-360.47	E^* - 125.72
	g	(² P _{3/2})	-367.47	E^* - 132.72
Cd ⁺⁺	g	4d ¹⁰ (¹ S ₀)	-624.44	I^* - 388.24
	aq.		17.6	
Cd ₂	g		- 6.7	D^* - 46.0
CdO	c		65.2	
CdH	g	² Σ	- 62.3	D^* - 15.47
CdH*	g	² Σ ₁	-143.0	
CdH ⁺	g	² Σ	-232.1	
Cd(OH) ₂	c	ppt.	133.6	
CdF ₂	1200		172.5	
CdCl ₂	liq.			F 10.5 ⁵⁸⁸
	c		93.0	S 3.09 ₄₀₀
	400		96.06	
	200		95.89	
	100		95.73	
	50		95.60	
	20		95.01	
	10		93.37	
	c		163.81	S 0.63 ₄₀₀
	c		269.98	S - 2.94 ₄₀₀
CdCl ₂ ·4H ₂ O	c		463.2	
CdCl ₂ ·2HCl·7H ₂ O	c		655.8	S - 2.3 ¹¹
CdCl ₂ ·CdO·H ₂ O	c		236.2	S 13.4 ¹⁵ _{HCl(aq.)}
CdBr	g		- 7.	D^* - 60.
CdBr*	g		- 96.6	E^* - 89.55
CdBr ₂	liq.			F - 5.0 ⁸⁸⁰
	c		75.8	S 0.44 ₄₀₀
	400		76.2	
CdBr ₂ ·4H ₂ O	c		357.0	S - 7.29 ₄₀₀
CdBr ₂ ·CdO·H ₂ O	c		217.7	S 14.3 ¹⁶ _{HBr(aq.)}
CdI	g		- 20.	D^* - 32.
CdI*	g		-104.1	E^* - 84.07
CdI ₂	g		4.0	V - 28.7 ⁷⁰⁰

Cadmium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
CdI ₂	liq.			<i>F</i> — 4.0 ⁴⁰⁰
	c		48.40	<i>S</i> — 0.96 ₄₀₀
	140C ₂ H ₅ OH			<i>S</i> 4.31 ¹³ _{140C₂H₅OH}
	144C ₂ H ₅ OH			<i>S</i> 6.65 ¹³ _{144C₂H₅OH}
	400		47.44	
CdI ₂ ·CdO·H ₂ O	c		180.7	<i>S</i> 25.8 ¹³ _{HI (aq.)}
CdS	c		34.6	
CdSO ₄	c		222.22	<i>S</i> 10.68 ₄₀₀
	400		232.906	
	200		232.70	
	100		232.553	
	50		232.352	
	30.6		231.828	
	20.6		231.494	
	15.6		231.128	
	13.6		230.194	
CdSO ₄ ·H ₂ O	c		295.23	<i>S</i> 6.05 ₄₀₀
CdSO ₄ ·2 $\frac{3}{2}$ H ₂ O	c		412.72	<i>S</i> 2.54 ₄₀₀
CdS ₂ O ₈	aq.		298.0	
CdSO ₄ ·2 $\frac{3}{2}$ H ₂ SO ₄	c		766.2	<i>S</i> — 4.7
CdSO ₄ ·2HCl	c		287.	<i>D</i> — 10.
CdSe	c		25.	
CdTe	c		16.	
CdN ₈	c		-106.2	<i>D</i> — 35.1
Cd(NO ₃) ₂	c		77 (?)	
	400		115.67	
Cd(NO ₃) ₂ ·H ₂ O	c		179.87	<i>S</i> 4.18 ₄₀₀
Cd(NO ₃) ₂ ·4H ₂ O	c		394.23	<i>S</i> — 5.04 ₄₀₀
CdCl ₂ ·NH ₃	c		122.0	<i>D</i> — 18.1
CdCl ₂ ·2NH ₃	c		149.5	<i>D</i> — 16.5
CdCl ₂ ·4NH ₃	c		192.8	<i>D</i> — 10.7
CdCl ₂ ·4NH ₄ Cl	c		394.4	<i>S</i> — 13.75 ¹⁵
CdCl ₂ ·6NH ₃	c		235.1	<i>D</i> — 10.2
CdCl ₂ ·10NH ₃	c		308.5	<i>D</i> — 7.4
CdCl ₂ ·NH ₄ Cl· $\frac{1}{2}$ H ₂ O	c		206.6	<i>S</i> — 5.36
CdBr ₂ ·NH ₃	c		104.8	<i>D</i> — 18.1
CdBr ₂ ·2NH ₃	c		131.9	<i>D</i> — 16.9
CdBr ₂ ·6NH ₃	c		219.3	<i>D</i> — 10.7
CdBr ₂ ·12NH ₃	c		330.6	<i>D</i> — 7.6
CdBr ₂ ·NH ₄ Br· $\frac{1}{2}$ H ₂ O	c		177.4	<i>S</i> — 7.2 ¹⁶
CdI ₂ ·2NH ₃	c		98.0	<i>D</i> — 16.6
CdI ₂ ·6NH ₃	c		191.0	<i>D</i> — 11.7
CdI ₂ ·NH ₄ I· $\frac{1}{2}$ H ₂ O	c		134.5	<i>S</i> — 7.88 ¹⁵
CdSO ₄ ·NH ₃	c		250.8	<i>D</i> — 17.6
CdSO ₄ ·2NH ₃	c		277.7	<i>D</i> — 16.0

Cadmium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
$CdSO_4 \cdot 5NH_3$	c		346.9	$D - 12.1$
$CdSO_4 \cdot 6NH_3$	c		369.	$D - 11.2$
$CdSb$	c		2.7	
Cd_3Sb_2	c		4.0	
$CdCO_3$	c		178.6	
$Cd(CN)_2$	c		- 35.3	$S \quad 8.3^{20} H_2SO_4(aq.)$
$Cd(ONC)_2$	c	cadmium fulminate	- 36.3	$D - 44.5$
$Cd(CN)_2 \cdot CdO \cdot 5H_2O$	c		467.2	$S \quad 12.6 H_2SO_4(aq.)$
$2CdI_2 \cdot PbI_2$	c		128.4	$S \quad 8.30^{15}_{1000}$

Mercury

Atomic number 80

Standard state Hg (liq.)

Atomic weight 200.61

Hg	g	$6s^2 \quad ({}^1S_0)$	- 14.60	$V - 14.60$
	liq.		0.000	
	c			$F - 0.55^{-40}$
Hg*	g	$6s6p \quad ({}^3P^1_0)$	- 121.77	
	g	$({}^3P^1_1)$	- 126.80	
	g	$({}^3P^1_2)$	- 139.99	
	g	$({}^1P^1_0)$	- 168.52	
Hg ⁺	g	$5d^{10}6s \quad ({}^3S_{1/2})$	- 255.69	$I^* - 239.64$
Hg ⁺ *	g	$5d^96s^2 \quad ({}^2D_{5/2})$	- 356.79	$E^* - 101.10$
	g	$({}^2D_{3/2})$	- 399.60	$E^* - 143.91$
	g	$5d^{10}6p \quad ({}^2P^1_{1/2})$	- 402.26	$E^* - 146.57$
	g	$({}^2P^1_{3/2})$	- 428.20	$E^* - 172.51$
Hg ⁺⁺	g	$5d^{10} \quad ({}^1S_0)$	- 687.81	$I^* - 430.66$
	aq.		- 41.6	
Hg ₂	g		- 27.8	
Hg ₂ ⁺⁺	aq.		- 40.	
HgO	c	red	21.6	
HgO	c	yellow ppt.	20.8	
Hg ₂ O	c		21.6	
HgH	g		- 57.1	$D^* - 8.5$
HgH*	g	${}^2\Pi_{1/2}$	- 128.1	$E^* - 70.97$
	g	${}^3\Pi_{3/2}$	- 138.6	$E^* - 81.46$
HgH ⁺	g	${}^1\Sigma$	- 272.3	$D^* - 34.4$
HgCl	g		- 10.	
HgCl*			- 123.0	$E^* - 113.0$
HgCl ₂	g		33.3	$V - 14.6^{382}$
	liq.			$F - 4.1^{277}$

Mercury

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
HgCl ₂	c		53.4	<i>S</i> — 3.32 ₃₀₃
	aq.		50.1	
HgCl ₄ ⁻⁻	aq.		130.9	
Hg ₂ Cl ₂	c		63.15	
HgCl ₂ ·HgO	c		75.6	
HgCl ₂ ·2HgO	c		97.4	
HgCl ₂ ·3HgO	c		119.1	
HgCl ₂ ·4HgO	c		140.9	
HgBr	g		— 16.	
HgBr ₂	g		21.6	<i>V</i> — 14.6 ²¹⁸
	liq.			<i>F</i> — 4.5 ²³⁶
	c		40.70	<i>S</i> — 2.4
	aq.		38.3	
HgBr ₄ ⁻⁻	aq.		99.4	
Hg ₂ Br ₂	c		49.2	
HgBr ₂ ·HgO	c		63.0	
HgBr ₂ ·2HgO	c		84.8	
HgBr ₂ ·3HgO	c		106.7	
HgI	g		— 21.	
HgI ₂	g		5.0	<i>V</i> — 15.0 ²⁸⁰
	liq.			<i>F</i> — 4.6 ²⁵⁶
	c	I, yellow	24.65	<i>T</i> 0.65 ¹²⁷ — II
	c	II, red	25.3	
HgI ₄ ⁻⁻	aq.		55.4	
Hg ₂ I ₂	c	yellow	28.87	
HgS	c	red	11.0	
	c	black	10.7	
HgSO ₄	c		166.6	
HgSO ₄ ·4H ₂ SO ₄	400		1016.2	
Hg ₂ SO ₄	c		176.5	
(HgO) ₂ SO ₃	c		218.9	<i>S</i> 43.4 ₆ HCl(aq.)
HgSe	c		8.0	
Hg ₂ N ₄	c		— 100.	
Hg(NO ₃) ₂	aq.		56.6	
Hg(NO ₃) ₂ · $\frac{1}{2}$ H ₂ O	c		91.5	<i>S</i> — 1.4HNO ₂ (aq.)
Hg ₂ (NO ₃) ₂	aq.		58.3	
Hg ₂ (NO ₃) ₂ ·HNO ₃	100		106.4	
Hg ₂ (NO ₃) ₂ ·2H ₂ O	c		206.5	<i>S</i> 33.5KCl(aq.)
Hg(NO ₃) ₂ ·2HgO·H ₂ O	c		244.6	<i>S</i> 3.8HNO ₂ (aq.)
(Hg ₂ N) ₂ O	c	Millon's oxide	— 77.0	<i>S</i> 151.0KCN(aq.)
	aq.		— 73.4	<i>S</i> 3.6
Hg ₂ NOH	c	Millon's hydroxide	— 2.8	<i>S</i> 74.KCN(aq.)
Hg ₂ NOH· $\frac{1}{2}$ H ₂ O	c		104.0	<i>S</i> 70.1KCN(aq.)
Hg ₂ NOH·2H ₂ O	c	Millon's base	189.0	<i>S</i> 68.9KCN(aq.)
Hg ₂ NOH·4H ₂ O	c		326.4	<i>S</i> 68.3KCN(aq.)
HgF ₂ ·2NH ₃	c			

Mercury

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HgF ₂ ·4NH ₃	c	Millon's chloride		<i>D</i> — 11.5
HgF ₂ ·5NH ₃	c			<i>D</i> — 8.6
HgCl ₂ ·2NH ₃	c		108.5	<i>S</i> 34.5 _{HCl(aq.)}
HgCl ₂ ·8NH ₃	c		222.9	<i>D</i> — 8.1
HgCl ₂ ·9½NH ₃	c		250.1	<i>D</i> — 7.2
Hg ₂ NCl	c		— 6.	
Hg ₂ NCl·½H ₂ O	c		31.2	
Hg ₂ NCl·H ₂ O	c		68.4	
Hg ₂ NCl·½NH ₃	c		5.6	<i>S</i> 60.7 _{KCN(aq.)}
Hg ₂ Cl ₂ ·2NH ₃	c		113.5	<i>D</i> — 14.3
Hg ₂ NCl·NH ₃	c		15.8	<i>S</i> 54.6 _{KCN(aq.)}
Hg ₂ NCl·NH ₄ Cl	c		141.5	<i>S</i> 54.5 _{KCN(aq.)}
Hg ₂ NCl·3NH ₄ Cl	c		289.6	<i>S</i> 48.8 _{KCN(aq.)}
Hg ₂ NCl·½HgCl ₂	c		24.0	<i>S</i> 81.1 _{KCN(aq.)}
HgBr ₂ ·2NH ₃	c		95.0	<i>S</i> 20.4 _{KCN(140)}
HgBr ₂ ·2NH ₄ Br	aq.	Millon's bromide	161.	
HgBr ₂ ·8NH ₃	c		207.5	<i>D</i> — 7.8
Hg ₂ NBr	c		— 14.9	<i>S</i> 60.5 _{KCN(aq.)}
Hg ₂ NBr·NH ₄ Br	c		57.0	<i>S</i> 50.2 _{KCN(aq.)}
Hg ₂ NBr·3NH ₄ Br	c		188.6	<i>S</i> 44.3 _{KCN(aq.)}
Hg ₂ NBr·½HgBr ₂	c		— 1.8	<i>S</i> 65.6 _{KCN(aq.)}
Hg ₂ NBr·¾HgBr ₂	c		10.9	
HgI ₂ ·½NH ₃	c		43.3	
HgI ₂ ·2NH ₃	c		71.8	<i>S</i> 13.8 _{KCN(aq.)}
HgI ₂ ·8NH ₃	c		145.8	<i>D</i> — 7.8
Hg ₁₀₀ Bi	liq.	mercuric oxalate	— 3.7	
HgC ₂ O ₄	c		160.2	<i>S</i> 7.0 ⁹ _{HCl(100)}
Hg(CH ₃) ₂	liq.		— 37.8	
Hg(C ₂ H ₅) ₂	liq.	mercuric acetate	— 15.4	
Hg(C ₂ H ₃ O ₂) ₂	c		198.0	<i>S</i> — 4.0 ₄₄₀
	aq.		194.0	
HgH ₂ (C ₂ H ₃ O ₂) ₄	aq.		431.7	
Hg ₂ (C ₂ H ₃ O ₂) ₂	c		203.3	<i>S</i> 36.6 _{KI(aq.)}
Hg(C ₂ H ₃ O ₂) ₂ ·HgO	c		219.0	
HgCl ₂ ·CH ₃ OH	c		113.7	<i>D</i> — 11.7 ²⁰
Hg(CN) ₂	c		— 61.8	<i>S</i> — 3.0
	aq.		— 64.8	
Hg(CN) ₄ [—]	aq.		124.7	
HgC ₂ N ₂ O ₂	c	mercurous acetate	— 64.1	<i>D</i> — 117.7
Hg(CN) ₂ ·½HgO	c		— 52.0	<i>S</i> 0.1 _{HCl(aq.)}
Hg(CN) ₂ ·HgO	c		— 39.2	<i>S</i> 13.6 _{HCl(aq.)}
Hg(CN) ₂ ·NH ₄ CN	400		— 61.0	
Hg(CN) ₂ ·2NH ₄ CN	600		— 59.	
Hg(CN) ₂ ·HgCl	c		— 8.9	<i>S</i> — 5.4 ¹⁴
Hg(CN) ₂ ·NH ₄ Cl	500		6.6	
Hg(CN) ₂ ·NH ₄ Cl·½H ₂ O	c		65.4	<i>S</i> — 7.55 ¹⁵

Mercury

Formula	State	Description	Q_f , kcal. mole^{-1}	Q , kcal. mole^{-1}
$\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{Br}$	500		— 4.0	
$\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{Br} \cdot \text{H}_2\text{O}$	c		74.8	$S - 10.48^{16}$
$\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{I}$	500		— 17.6	
$\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{I} \cdot \frac{1}{2}\text{H}_2\text{O}$	c		11.8	$S - 12.25$
$\text{Hg}(\text{SCN})_2$	c		— 52.0	
Hg_{50}Sn	liq.		— 2.54	
Hg_{100}Sn	liq.		— 2.54	
HgPb_2	c		— 0.05	
Hg_{100}Pb	liq.		— 2.51	
Hg_{260}Pb	liq.		— 2.63	
$\text{Hg}_{1000}\text{Pb}$	liq.		— 2.66	
$\text{Hg}_{\infty}\text{Pb}$	liq.		— 2.70	
Hg_5Tl_2	c		2.50	
$\text{Hg}_{7.2}\text{Tl}$	liq.		— 2.94	
$\text{Hg}_{8.1}\text{Tl}$	liq.		— 3.44	
$\text{Hg}_{9.8}\text{Tl}$	liq.		— 4.56	
$\text{Hg}_{16.2}\text{Tl}$	liq.		— 5.06	
$\text{Hg}_{21.6}\text{Tl}$	liq.		— 5.48	
$\text{Hg}_{31.6}\text{Tl}$	liq.		— 5.85	
$\text{Hg}_{54.5}\text{Tl}$	liq.		— 6.47	
Hg_{32}Zn	liq.		— 2.25	
Hg_{65}Zn	liq.		— 2.31	
$\text{HgBr}_2 \cdot \text{ZnBr}_2$	4400		132.6	
$\text{HgBr}_2 \cdot 2\text{ZnBr}_2$	4800		228.6	
$2\text{HgBr}_2 \cdot \text{ZnBr}_2$	8400		170.5	
$\text{Hg}(\text{CN})_2 \cdot \text{ZnCl}_2$	1000		— 14.7	
$\text{Hg}(\text{CN})_2 \cdot \text{ZnCl}_2 \cdot 7\text{H}_2\text{O}$	c		477.2	$S - 13.4^{15}$
$\text{ZnBr}_2 \cdot \text{Hg}(\text{CN})_2$	1000		— 35.6	
$\text{ZnBr}_2 \cdot \text{Hg}(\text{CN})_2 \cdot 8\text{H}_2\text{O}$	c		532.4	$S - 20.8$
Hg_{55}Cd	liq.		0.50	
HgCd_3	c		0.74	
HgCd	c		1.96	
Hg_3Cd	c		3.99	
$\text{Hg}_{3.5}\text{Cd}$	c		4.27	
Hg_4Cd	c		3.92	
Hg_{10}Cd	c		0.5002	
$\text{HgBr}_2 \cdot \text{CdBr}_2$	4400		115.9	
$\text{HgBr}_2 \cdot 2\text{CdBr}_2$	4800		193.3	
$2\text{HgBr}_2 \cdot \text{CdBr}_2$	8400		153.0	
$\text{Hg}(\text{CN})_2 \cdot \text{CdCl}_2$	660		31.5	
$\text{Hg}(\text{CN})_2 \cdot \text{CdCl}_2 \cdot 2\text{H}_2\text{O}$	c		177.5	$S - 9.3^{15}$
$\text{Hg}(\text{CN})_2 \cdot \text{CdBr}_2$	660		12.0	
$2\text{Hg}(\text{CN})_2 \cdot \text{CdBr}_2$	1100		— 52.8	
$\text{Hg}(\text{CN})_2 \cdot \text{CdBr}_2 \cdot 3\text{H}_2\text{O}$	c		229.6	$S - 12.5^{14}$
$2\text{Hg}(\text{CN})_2 \cdot \text{CdI}_2$	1100		— 80.1	
$2\text{Hg}(\text{CN})_2 \cdot \text{CdI}_2 \cdot 8\text{H}_2\text{O}$	c		489.2	$S - 22.3^{15}$

Copper

Atomic number 29

Standard state Cu (c)

Atomic weight 63.57

Formula	State	Description	Q_f , kcal. $mole^{-1}$	Q , kcal. $mole^{-1}$
Cu	g	3d ¹⁰ 4s (² S _{1/2})	- 81.2	
	liq.			F - 3.2 ¹⁰⁸³
	c		0.000	
Cu*	g	3d ⁹ 4s ² (² D _{3/2})	-113.09	E° - 31.89
	g	(² D _{5/2})	-119.91	E° - 38.71
	g	3d ¹⁰ 4p (² P _{1/2})	-168.13	E° - 86.93
	g	(³ P _{3/2})	-168.83	E° - 87.63
Cu ⁺	g	3d ¹⁰ (¹ S ₀)	-162.23	I° -177.38
Cu ⁺ *	g	3d ⁹ 4s (³ D ₃)	-224.65	E° - 62.42
	g	(³ D ₂)	-227.26	E° - 65.03
	g	(³ D ₁)	-230.54	E° - 68.31
	g	(¹ D ₁)	-236.96	E° - 74.73
Cu ⁺⁺	g	3d ⁹ (² D _{5/2})	-629.51	I° -465.83
	aq.		- 15.1	
CuO	liq.			F - 13.3 ¹³³⁶
	c		38.5	
Cu ₂ O	liq.			F - 18.4 ¹²³⁶
	c		42.5	
CuH	g	¹ Σ	- 62.3	D° - 69.9
	c		- 5.12	S 8.93 _{CuCl₂(aq.)}
CuH*	g	¹ Σ	-128.65	E° - 66.35
Cu(OH) ₂	c	blue ppt.	106.70	
	c	green ppt.	106.96	S 14.46 _{HNO₃(aq.)}
3CuO·H ₂ O	c	brown	180.4	S 15.76 _{HNO₃(aq.)}
CuF ₂	aq.		141.7	
CuCl	c		34.3	S - 6.44 ²⁵ ₆₀₀
	HCl(aq.)		27.9	
CuCl ₂ -	aq.		67.7	
CuCl ₂	c		53.4	S 11.12 ₆₀₀
	800		64.6	
	400		64.5	
	200		64.0	
	100		63.55	
	50		62.84	
	30		61.96	
	20		61.13	
	10		59.49	
	200C ₂ H ₅ OH		58.43	
	100C ₂ H ₅ OH		58.31	
	50C ₂ H ₅ OH		58.12	
	40C ₂ H ₅ OH		58.05	
	30C ₂ H ₅ OH		57.91	
CuCl ₂ ·2H ₂ O	c		197.0	S 3.71 ₂₀₀
Cu ₂ Cl ₂	g			V - 19.2 ¹³⁰⁰

Copper

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Cu ₂ Cl ₂	liq. c	= 2 CuCl (c)	68.6	F — 7.74 ⁴³⁰
CuClO ₄	aq.		28.2	
Cu(ClO ₃) ₂	400		24.3	
Cu(ClO ₄) ₂	aq.		64.9	
CuO·CuCl ₂	c		90.	
Cu ₂ OCl ₂	c		121.3	
CuCl ₂ ·3CuO	c		168.6	S 54.9 _{HCl(aq.)}
CuCl ₂ ·3CuO·4H ₂ O	c	atacamite	464.1	S 33.0 _{HCl(aq.)}
HCuCl ₂	aq.		67.7	
CuBr	c		26.7	
CuBr ₂	c		34.0	S 8.25 ²⁰ ₄₀₀
	aq.		42.2	
CuBr ₂ ·4H ₂ O	c		317.2	S — 1.
Cu ₂ Br ₂	g			V — 18.8 ¹⁰⁰⁰
	c	= 2 CuBr (c)	53.4	
CuBr ₂ ·3Cu(OH) ₂	c		374.2	S 32.4 _{HBr(aq.)}
CuI	g		— 8.	
	c		17.8	
CuI ₂	c		4.8	
	aq.		11.7	
Cu ₂ I ₂	g			V — 18.9 ¹³⁰⁰
	c	= 2 CuI (c)	35.6	
CuS	c		11.6	
Cu ₂ S	c	I		T 1.05 ²⁶⁰ _{-II}
	c	II		T 1.31 ⁹¹ _{-III}
	c	III	18.97	
CuSO ₄	c		184.7	S 15.90 ₈₀₀
	800		200.64	
	200		200.6	
	100		200.52	
	60		200.48	
CuSO ₄ ·H ₂ O	c		259.7	S 9.33 ₈₀₀
CuSO ₄ ·3H ₂ O	c		402.1	S 3.61 ₈₀₀
CuSO ₄ ·5H ₂ O	c		545.34	S — 2.80 ₈₀₀
CuS ₂ O ₆	aq.		265.1	
CuS ₂ O ₆ ·5H ₂ O	c		611.9	S — 4.89 ₄₀₀
Cu ₂ SO ₄	c		179.6	
	aq.		191.2	
3CuO·CuSO ₄	c		302.	
CuSO ₄ ·3CuO·4H ₂ O	c		389.8	S 48.0 _{H₂SO₄(aq.)}
CuSO ₄ ·2HCl	c		245.	D — 8.2
CuSe	c		19.	
Cu ₂ Se	c	I		T 1.12 ¹¹⁰ _{-II}
	c	II	14.5	S 112. bromine water

Copper

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CuSeO ₄	400		130.2	
CuSeO ₄ ·5H ₂ O	c		474.8	<i>S</i> — 2.66
Cu ₂ Te	c		6.0	
CuN ₃	c		— 56.8	
Cu(NO ₃) ₂	c		73.1	<i>S</i> 10.47 ⁸ ₂₈₀
	200		83.4	
	100		83.45	
	50		83.58	
	20		83.61	
	15		83.42	
	12		83.14	
	10		82.67	
Cu(NO ₃) ₂ ·3H ₂ O	c		291.1	<i>S</i> — 2.5 ¹⁵
Cu(NO ₃) ₂ ·6H ₂ O	c		504.3	<i>S</i> — 10.71 ₄₀₀
Cu(NO ₃) ₂ ·3CuO·3H ₂ O	c		415.5	<i>S</i> 34.0 _{HNO₃(aq.)}
Cu4NH ₃ ⁺⁺	aq.		80.1	
Cu6NH ₃ ⁺⁺	aq.		120.6	
Cu8NH ₃ ⁺⁺	aq.		163.3	
Cu12NH ₃ ⁺⁺	aq.		237.2	
Cu(NO ₃) ₂ ·2NH ₃	c		139.5	
Cu(NO ₃) ₂ ·4NH ₃	c		196.2	<i>D</i> — 17.4
	aq.		178.8	<i>S</i> — 17.4
Cu(NO ₃) ₂ ·6NH ₃	c		255.2	<i>D</i> — 9.8
CuCl·NH ₃	c		62.2	<i>D</i> — 16.7
CuCl·1½NH ₃	c		74.0	<i>D</i> — 12.6
CuCl ₂ ·2NH ₃	c		120.0	<i>S</i> 7.7 _{HCl(aq.)}
CuCl ₂ ·2NH ₃ ·½H ₂ O	c		136.1	<i>S</i> 2.6 _{12NH₃(aq.)}
CuCl ₂ ·2NH ₄ Cl	c		201.6	<i>S</i> 4.5 ¹⁵ ₅₅₀
CuCl ₂ ·2NH ₄ Cl·2H ₂ O	c		349.1	<i>S</i> — 6.2
CuCl·3NH ₃	c		104.5	<i>D</i> — 9.5
CuCl ₂ ·3½NH ₃	c		153.1	<i>D</i> — 14.1
CuCl ₂ ·4NH ₃	aq.		159.7	
CuCl ₂ ·4NH ₃ ·2H ₂ O	c		311.0	<i>S</i> — 12.4 _{2NH₃(aq.)}
CuCl ₂ ·5NH ₃	c		191.7	<i>D</i> — 12.2
CuCl ₂ ·5NH ₃ ·½H ₂ O	c		224.1	<i>S</i> — 9.3
CuCl ₂ ·5NH ₃ ·1½H ₂ O	c		292.7	<i>S</i> — 9.5
CuCl ₂ ·6NH ₃	c		217.	<i>D</i> — 15.
	aq.		200.7	
CuCl ₂ ·10NH ₃	c		284.7	<i>D</i> — 7.6
Cu(ClO ₂) ₂ ·4NH ₃	c			<i>D</i> — 15.6
Cu(ClO ₂) ₂ ·6NH ₃	c			<i>D</i> — 9.8
Cu(ClO ₄) ₂ ·4NH ₃	c			<i>D</i> — 20.0
Cu(ClO ₄) ₂ ·6NH ₃	c			<i>D</i> — 11.6
CuBr·NH ₃	c		52.3	<i>D</i> — 14.6
CuBr·1½NH ₃	c		64.3	<i>D</i> — 13.1

Copper

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CuBr·3NH ₃	c		95.0	D — 9.4
CuBr ₂ ·2NH ₃	c		98.0	S — 4.8 _{HCl(20)}
CuBr ₂ ·3½NH ₃	c		133.4	D — 15.6
CuBr ₂ ·5NH ₃	c		173.1	D — 12.9
CuBr ₂ ·6NH ₃	c		193.2	D — 9.1
CuBr ₂ ·10NH ₃	c		268.2	D — 7.8
CuI·½NH ₃	c		30.6	D — 15.5
CuI·NH ₃	c		44.0	D — 14.7
CuI·2NH ₃	c		66.0	D — 11.30
CuI·3NH ₃	c		87.6	D — 10.4
CuI ₂ ·2NH ₃	c		67.7	
CuI ₂ ·3½NH ₃	c		102.6	D — 15.2
CuI ₂ ·5NH ₃	c		142.8	D — 13.2
CuI ₂ ·10NH ₃	c		242.8	D — 7.0
Cu(IO ₃) ₂ ·5NH ₃	c			D — 12.7
CuSO ₄ ·NH ₃	c		215.0	S — 22.0 _{27NH₃(aq.)}
CuSO ₄ ·2NH ₃	c		245.3	S — 11.0 _{25NH₃(aq.)}
CuSO ₄ ·4NH ₃	c		297.1	S — 1.87 _{24NH₃(aq.)}
	aq.		292.4	
CuSO ₄ ·4NH ₃ ·1½H ₂ O	c		403.9	S — 7.1 _{2NH₃(aq.)}
CuSO ₄ ·5NH ₃	c		322.9	
CuSO ₄ ·6NH ₃	c		323.6	
	aq.		333.1	
CuSO ₄ ·8NH ₃	aq.		372.7	
CuSO ₄ ·12NH ₃	aq.		451.1	
CuS ₂ O ₆ ·4NH ₃	c			D — 19.3
CuS ₂ O ₆ ·5NH ₃	c			D — 10.4
CuS ₂ O ₆ ·4NH ₃	c			D — 13.0
CuSO ₄ ·(NH ₄) ₂ SO ₄	c		462.1	S — 9.85 ¹⁴
CuSO ₄ ·(NH ₄) ₂ SO ₄ ·2H ₂ O	c		597.1	
CuSO ₄ ·(NH ₄) ₂ SO ₄ ·6H ₂ O	c		892.8	S — 10.6
CuP ₂	c		1.0	
Cu ₃ Sb	c		2.5	
Cu(CHO ₂) ₂	c	cupric formate	182.2	S — 0.52 ¹⁵ ₈₀₃
	aq.		182.7	
Cu(CHO ₂) ₂ ·4H ₂ O	c		464.0	S — 7.8 ¹⁰ ₅₀₀
Cu(C ₂ H ₃ O ₂) ₂	c	cupric acetate	216.4	S — 2.4 ¹⁶ ₂₂₀
	aq.		218.8	
Cu(C ₂ H ₃ O ₂) ₂ ·H ₂ O	c		463.2	S — 0.17 ₄₀₀
Cu(C ₂ H ₃ O ₂) ₂	c	cupric glycollate	299.3	S — 1.62
	aq.		297.7	
CuCO ₃ ·Cu(OH) ₂	c		192.1	
CuCl ₂ ·2CH ₃ OH	c		164.1	D — 13.45
Cu ₂ Cl ₂ ·CO·2H ₂ O	c		227.3	
	aq.		223.9	

Copper

Formula	State	Description	Q_f , <i>kcal. mole</i> ⁻¹	Q , <i>kcal. mole</i> ⁻¹
Cu(C ₂ H ₅ SO ₄) ₂	aq.	cupric ethyl-sulfate	428.4	
CuCN	aq.		- 20.9	
CuONC	c	cuprous fulminate	23.2	
CuC ₂ O ₄ ·5NH ₃	c	cupric oxalate ammine		<i>D</i> - 10.8
Cu(CHO ₂) ₂ ·4NH ₃	c	cupric formate ammine		<i>D</i> - 11.7
Cu(C ₂ H ₃ O ₂) ₂ ·4NH ₃	c	cupric acetate ammine		<i>D</i> - 12.2
Cu(SCN) ₂ ·4NH ₃	c			<i>D</i> - 13.7
Cu(SCN) ₂ ·6NH ₃	c			<i>D</i> - 8.9
Cu ₃ Sn	c		8.0	
Cu ₂ Zn ₃	c		16.	
Cu ₂ Cd ₃	c		3.0	
CuSO ₄ ·Ti ₂ SO ₄ ·6H ₂ O	c			<i>D</i> - 14.8

Silver

Atomic number 47

Standard state Ag (c)

Atomic weight 107.880

Ag	g	4d ¹⁰ 5s (² S _{1/2})	- 68.0	
	liq.			<i>F</i> - 2.7 ⁹⁶¹
	c		0.000	
Ag*	g	4d ¹⁰ 5p (² P _{1/2})	-152.13	<i>E</i> ² - 84.13
	g	(² P _{3/2})	-154.74	<i>E</i> ² - 86.74
Ag ⁺	g	4d ¹⁰ (¹ S ₀)	-243.40	<i>I</i> ² -173.96
	aq.		- 25.2	
Ag ⁺ *	g	4d ⁹ (² D _{5/2})5s (² D ₃)	-354.89	<i>E</i> ² -111.49
	g	(³ D ₂)	-355.04	<i>E</i> ² -111.64
	g	4d ⁹ (² D _{3/2})5s ² D ₁	-367.86	<i>E</i> ² -124.46
	g	¹ D ₂	-366.78	<i>E</i> ² -123.38
Ag ⁺⁺	g	4d ⁹ (² D _{5/2})	-748.	<i>I</i> ² -504.
Ag ⁺⁺⁺	g	4d ⁸	-1533.	<i>I</i> ² -785.
Ag ₂ O	c		6.95	
Ag ₂ O ₂	c		5.95	
AgH	g		- 64.	
AgF	c		48.7	<i>S</i> 4.3 ¹⁰
	amorp.	red	48.7	<i>S</i> 4.3 ¹⁶
	400		53.0	
AgF·H ₂ O	c		120.5	<i>S</i> 0.85 ¹⁰
AgF·2H ₂ O	c		191.25	<i>S</i> - 1.5 ¹⁰

Silver

Formula	State	Description	Q_f , kcal. mole^{-1}	Q , kcal. mole^{-1}
$\text{AgF} \cdot 4\text{H}_2\text{O}$	c		331.45	$S - 4.9^{13}$
Ag_2F	c		50.3	$S - 2.75$
AgHF_2	aq.		130.6	
AgCl	g		— 26.5	$V - 44.3^{1300}$
	liq.			$F - 3.1^{450}$
	c		30.30	
AgCl^*	g		— 116.4	$E^* - 89.89$
Ag_2Cl	c	(?)	30.7	
AgClO_3	c		1.8	$S - 7.52^{600}$
	aq.		— 5.7	
AgClO_4	c		12.2	$S - 2.17^{12}_{1000}$
	aq.		14.4	
AgBr	g		— 27.2	$V - 40.8^{1100}$
	liq.			$F - 2.4^{434}$
	c	ppt.	23.81	
AgI	g		— 33.5	$V - 38.6^{1000}$
	c	I, cubic		$T - 1.27^{247}_{-II}$
	c	II, hexagonal	14.94	
AgI_3 ---	aq.		43.9	
$3\text{AgI} \cdot \text{HI} \cdot 7\text{H}_2\text{O}$	c		539.0	$S - 2.1$
Ag_2S	c	I		$T - 0.95^{175}_{-II}$
	c	II	5.5	
Ag_2SO_4	c		170.1	
	aq.		165.6	
$\text{Ag}(\text{S}_2\text{O}_3)_2$ ---	aq.		284.	
$\text{Ag}_2\text{S}_2\text{O}_8$	aq.		230.0	
$\text{Ag}_2\text{S}_2\text{O}_8 \cdot 2\text{H}_2\text{O}$	c		377.1	$S - 10.36^{400}$
$\text{Ag}_2\text{SO}_4 \cdot 2\text{HCl}$	c		244.	$D - 15.3^{300}$
Ag_2Se	c	I		$T - 1.66^{133}_{-II}$
	c	II	1.	
Ag_2SeO_4	c		95.9	$S - 89.4$ bromine water
AgN_3	c		— 67.3	
AgNO_2	c		11.6	$S - 8.8$
	aq.		2.8	
AgNO_3	liq.			$F - 2.76^{212}$
	c	I		$T - 0.57^{159}_{-II}$
	c	II	29.4	$S - 5.46$
	200		23.96	
$\text{Ag}_2\text{N}_2\text{O}_3$	c		— 29.1	
$\text{Ag}(\text{NH}_3)_2^+$	aq.		24.6	
$\text{Ag}_2\text{O} \cdot \text{HNO}_3 \cdot 2\text{H}_2\text{O}$	liq.		19.9	
$\text{AgNO}_3 \cdot 3\text{NH}_3$	c			$D - 18.7$
$\text{AgNO}_3 \cdot \text{NH}_3$	c		59.9	
$\text{AgNO}_3 \cdot 2\text{NH}_3$	c		84.8	$S - 9.05^{14}_{1000}$
	aq.		75.7	
$\text{AgNO}_3 \cdot 3\text{NH}_3$	c		105.5	$S - 10.44^{12}_{1000}$

Silver

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
AgNO ₃ ·3NH ₃	aq.		95.1	
Ag(NH ₃) ₂ OH	aq.		198.2	
AgCl·NH ₃	c		53.6	<i>D</i> - 11.2
AgCl·1½NH ₃	c		64.8	<i>D</i> - 10.6
AgCl ₂ ·NH ₃	c		96.9	<i>D</i> - 9.3
AgClO ₄ ·2NH ₃	c		76.8	<i>S</i> - 10.71
	aq.		66.1	
AgClO ₄ ·3NH ₃	c		96.9	<i>S</i> - 11.18
	aq.		85.7	
AgBr·NH ₃	c		45.5	<i>D</i> - 10.6
AgBr·1½NH ₃	c		55.9	<i>D</i> - 9.95
AgBr·3NH ₃	c		85.3	<i>D</i> - 8.6
AgBrO ₃ ·3NH ₃	c			<i>D</i> - 8.45
AgI·½NH ₃	c		26.2	<i>D</i> - 11.6
AgI·NH ₃	c		36.0	<i>D</i> - 8.6
AgI·1½NH ₃	c		45.1	<i>D</i> - 6.9
AgI·2NH ₃	c		54.1	<i>D</i> - 6.8
AgI·3NH ₃	c		71.9	<i>D</i> - 6.7
AgP ₃	c		- 2.6	
Ag ₂ C ₂	c		- 83.6	
Ag ₂ CO ₃	c		119.9	
Ag ₂ C ₂ O ₄	c	silver oxalate	159.6	
AgC ₂ H ₃ O ₂	c	silver acetate	96.8	<i>S</i> - 4.40
	aq.		92.4	
Ag ₂ C ₂ ·AgCl	c		- 50.0	<i>S</i> 11.8 _{HCl(aq.)}
2Ag ₂ C ₂ ·AgCl	c		- 130.2	<i>S</i> 23.3 _{HCl(aq.)}
Ag ₂ C ₂ ·AgI	c		- 67.3	<i>S</i> 12.65 _{HCl(aq.)}
Ag ₂ C ₂ ·2AgI	c		- 51.1	<i>S</i> 13.85 _{HCl(aq.)}
2Ag ₂ C ₂ ·Ag ₂ SO ₄	c		14.0	<i>S</i> 39.3 _{HCl(aq.)}
AgCN	c	silver cyanide	- 33.4	
Ag(CN) ₂ ⁻	aq.		- 61.75	
Ag(CN) ₃ ⁻⁻	aq.		- 98.0	
Ag ₂ C ₂ ·AgNO ₃	c		- 49.5	<i>S</i> 24.4 _{HCl(aq.)}
AgCN·NH ₃	c	silver cyanide ammine	8.0	<i>D</i> - 14.0
Ag ₂ CN ₂	c	silver cyanamide	- 50.0	<i>S</i> 19.25 _{HCl(aq.)}
AgCNO	c	silver cyanate	23.6	
AgONC	c	silver fulminate	- 42.8	
AgCl·CH ₃ NH ₂	c		50.	<i>D</i> - 12.2
AgBr·CH ₃ NH ₂	c		43.5	<i>D</i> - 13.6
AgI·CH ₃ NH ₂	c		36.2	<i>D</i> - 14.0
AgSCN	c		- 21.8	<i>S</i> - 21.3
	aq.		- 43.1	
AgI·PbI ₂	c			<i>T</i> - 2.6
Ag ₂ Hg ₄	c		0.7	
AgI·CuI	c	(?)		<i>T</i> - 2.9
AgI·2CuI	c	(?)		<i>T</i> - 8.7

Gold

Atomic number 79

Standard state Au (c)

Atomic weight 197.2

Formula	State	Description	Q_f , kcal, mole ⁻¹	Q , kcal. mole ⁻¹
Au	g	5d ¹⁰ s (2S _{1/2})	- 92.	
	liq.		0.000	F - 3.12 ¹⁰⁰³
Au*	c			
	g	5d ⁹ 6s ² (2D _{5/2})	-118.08	E^* - 26.08
	g	(2D _{3/2})	-153.01	E^* - 61.02
	g	5d ¹⁰ 6p (2P _{1/2})	-198.35	E^* -106.36
	g	(2P _{3/2})	-209.22	E^* -117.22
Au ⁺	g	5d ¹⁰ (1S ₀)	-305.44	I^* -211.97
Au ₂ O ₃	c		- 11.	
AuH	g		- 44.3	
Au(OH) ₃	c	ppt.	100.6	S 36.9 _{4HBr(aq.)}
AuCl	c		8.3	S 4.5 _{HCl(aq.)}
AuCl ₂	c		18.1	S 6.7 _{HCl(aq.)}
AuCl ₃	c		28.3	
	aq.		32.75	S 4.45 ₀₀₀
AuCl ₄ ⁻	aq.		76.7	
AuCl ₃ ·2H ₂ O	c		171.2	S - 1.69 ₀₀₀
HAuCl ₄	aq.		76.7	
HAuCl ₄ ·3H ₂ O	c		285.4	S - 3.55
HAuCl ₄ ·4H ₂ O	c		356.0	S - 5.83 ₄₀₀
AuBr	c		3.4	
AuBr ₂	c	(?)	5.6	S 6.7 _{HBr(aq.)}
AuBr ₃	c		14.5	S - 3.76 ₂₀₀
	aq.		10.8	
AuBr ₄ ⁻	aq.		47.1	
HAuBr ₄	aq.		47.1	
HAuBr ₄ ·5H ₂ O	c		400.3	S - 11.40 ₁₀₀₀
AuI	c		- 0.2	
AuCl·NH ₃	c		43.8	S 29.2 _{KCN(aq.)}
AuCl·2NH ₃	c		68.9	S 23.3 _{KCN(aq.)}
AuCl·6NH ₃	c		141.5	D - 7.2
AuBr·NH ₃	c		36.1	S 25.9 _{KCN(aq.)}
AuBr·2NH ₃	c		60.1	D - 12.2
AuBr·3NH ₃	c		79.3	D - 8.3
AuBr·4NH ₃	c		98.4	D - 8.1
AuBr·6NH ₃	c		136.2	D - 7.95
AuI·NH ₃	c		26.4	S 20.1 _{KCN(aq.)}
AuI·2NH ₃	c		46.4	D - 9.1
AuI·3NH ₃	c		66.3	D - 8.9
AuI·6NH ₃	c		123.1	D - 8.0
AuI·8NH ₃	c		157.6	D - 6.3
Au(CN) ₂ ⁻	aq.		- 57.5	
AuHg ₁₀₀	liq.		- 2.0	
AuAgCl ₂	c		38.5	
AuAgCl ₄	c		57.1	D - 18.2

Platinum

Atomic number 78

Standard state Pt (c)

Atomic weight 195.23

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Pt	g	5d ⁹ (² D _{3/2})6s(³ D ₃)	-127.	
	liq.			
	c		0.000	$F - 5.3^{1755}$
Pt*	g	5d ⁹ (² D _{5/2})6s(³ D ₂)	-129.21	$E^* - 2.21$
	g	5d ⁹ 6s ² (J=4)	-129.35	$E^* - 2.35$
	g	5d ¹⁰ (¹ S ₀)	-144.48	$E^* - 17.48$
Pt ⁺	g		-334.2	$I^* - 205.8$
Pt(OH) ₂	c		87.5	
PtCl	c		17.	$D - 34.$
PtCl ₂	c		34.	$D - 34.$
PtCl ₃	c		50.	$D - 32.$
PtCl ₄	c		62.6	$D - 25.2$
	aq.		82.0	
PtCl ₄ ·5H ₂ O	c		425.7	$S - 1.84_{400}$
PtCl ₄ --	aq.		122.0	
PtCl ₆ --	aq.		165.6	
H ₂ PtCl ₄	aq.		122.0	
H ₂ PtCl ₆	aq.		165.6	
HPtCl ₅ ·2H ₂ O	c		248.5	$S \quad 14.34_{HCl(aq.)}$
H ₂ PtCl ₆ ·6H ₂ O	c		571.5	$S \quad 4.34_{500}$
PtBr ₄	c		40.6	$S \quad 9.8_{1000}$
	aq.		50.4	
PtBr ₄ --	aq.		90.2	
PtBr ₆ --	aq.		115.9	
H ₂ PtBr ₆	aq.		115.9	
H ₂ PtBr ₆ ·9H ₂ O	c		733.8	$S - 2.86$
PtI ₄	c		18.	$S \quad 7.3_{2NaI(aq.)}$
PtI ₆ --	aq.		52.4	
PtS	c		16.	
PtS ₂	c		21.	
Pt(NH ₃) ₄ (OH) ₂	aq.		209.1	
PtCl ₂ ·2NH ₃	c		119.6	$D - 31.3$
(NH ₄) ₂ PtCl ₄	c		193.3	$S - 8.42$
	aq.		184.9	
Pt(NH ₃) ₄ Cl ₂	c		183.	
	aq.		178.9	
Pt(NH ₃) ₄ Cl ₂ ·H ₂ O	c		256.0	$S - 8.76$
PtCl ₂ ·5NH ₃	c		204.3	
PtI ₂ ·2NH ₃	c		x	
PtI ₂ ·4NH ₃	c		$x+54.1$	$D - 16.1$
PtI ₂ ·6NH ₃	c		$x+94.6$	$D - 9.3$
PtCl ₂ (NH ₃) ₄ SO ₄	aq.		311.4	
AgPtCl ₆	c		129.9	
AgPtBr ₆	c		97.3	

Iridium

Atomic number 77

Standard state Ir (c)

Atomic weight 193.1

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Ir	g	5d ⁹ (² D _{5/2})	-120.	$E^* - 8.07$
Ir	c		0.000	
Ir*		5d ⁹ (² D _{3/2})	-128.07	
IrO ₂	c		50.	
H ₂ IrI ₆				$D - 67.4$
IrF ₆	g		121.5	
	liq.		130.	
IrCl	c		20.5	
IrCl ₂	c		40.6	
IrCl ₃	c		60.5	
IrCl ₅ --	aq.		152.5	
IrCl ₆ ---	aq.		186.8	

Osmium

Atomic number 76

Standard state Os (c)

Atomic weight 191.5

Os	g		-125.	$F - 3.41^{40}$
	c		0.000	
OsO ₄	g		80.1	
	liq.			
	c		93.6	

Rhenium

Atomic number 75

Standard state Re (c)

Atomic weight 186.31

Re	c		0.000	
ReO ₃	c		83.	
Re ₂ O ₇	c		297.5	
ReO ₄ -	∞		224.2	
HReO ₄	∞		224.2	
	25600		223.6	
	12800		223.3	
	6400		223.0	
	4700		222.7	

Palladium

Atomic number 46

Standard state Pd (c)

Atomic weight 106.7

Formula	State	Description	Q_f , $kcal. mole^{-1}$	$Q, kcal. mole^{-1}$
Pd	g	$4d^{10} (^1S_0)$	-110.	$F - 3.65^{1540}$
	liq.			
Pd*	c		0.000	
	g	$4d^9 (^2D_{5/2})5s(^2D_3)$	-128.69	$E^* - 18.69$
	g	$(^3D_2)$	-132.08	$E^* - 22.08$
	g	$4d^9 (^2D_{3/2})5s(^3D_1)$	-138.73	$E^* - 28.73$
	g	$(^1D_2)$	-143.37	$E^* - 33.37$
Pd+	g	$4d^9 (^2D_{5/2})$	-302.3	$I^* - 191.83$
Pd+ *	g	$(^2D_{3/2})$	-312.3	$E^* - 10.00$
Pd++	g	$4d^8 (^4F_4)$	-761.	$I^* - 457.$
PdO	c		21.4	
Pd ₂ H	c		8.86	
Pd(OH) ₂	c		90.7	
Pd(OH) ₄	c		155.0	
PdCl ₂	c		44.2	
PdCl ₄ --	aq.		127.5	
PdCl ₆ --	aq.		156.5	
H ₂ PdCl ₄	aq.		127.5	
H ₂ PdCl ₆	aq.		156.5	
PdBr ₂	c		24.9	
PdBr ₄	aq.		85.5	
PdI ₂	c		15.1	
PdI ₂ ·H ₂ O	c		86.5	
PdCl ₂ ·2NH ₃	c		106.1	
PdCl ₂ ·4NH ₃	c		159.1	
PdI ₂ ·2NH ₃	c		71.0	
PdI ₂ ·4NH ₃	c		118.7	
Pd(CN) ₂	c		- 51.7	

Rhodium

Atomic number 45

Standard state Rh (c)

Atomic weight 102.91

Rh	g	$4d^8 (^4F)5s(^4F_{5/2})$	-115.	
Rh*	c		0.000	
	g	$4d^8 (^4F)5s(^4F_{7/2})$	-119.36	$E^* - 4.36$
	g	$(^3F_{5/2})$	-122.40	$E^* - 7.40$
	g	$(^4F_{3/2})$	-124.89	$E^* - 9.89$
Rh+	g	$4d^8 (^3F)$	-194.	$I^* - 178.$
RhO	c		25.	$D - 58.$
Rh ₂ O	c		21.	$D - 41.$
Rh ₂ O ₃	c		78.	$D - 56.$
RhCl	c		16.	$D - 32.$
RhCl ₂	c		40.	$D - 36.$
RhCl ₃	c		60.	$D - 40.$
RhCl ₆ ---	aq.		205.5	

Ruthenium

Atomic number 44

Standard State Ru (c)

Atomic weight 101.7

Formula	State	Description	Q_f , $kcal, mole^{-1}$	$Q, kcal. mole^{-1}$
Ru	g	4d ⁷ (⁴ F)5s (⁵ F ₅)	-120.	
	c		0.000	
Ru*	g	(⁵ F ₄)	-123.39	$E^* - 3.39$
	g	(⁵ F ₃)	-125.95	$E^* - 5.95$
	g	(⁵ F ₂)	-127.72	$E^* - 7.72$
	g	(⁵ F ₁)	-128.84	$E^* - 8.84$
Ru ⁺	g		-294.	$I^* - 173.$
RuO ₂	c		52.5	
RuCl ₃	c		63.	

Masurium

Atomic number 43

Standard state Ma (c)

Atomic weight (98?)

Nickel

Atomic number 28

Standard state Ni (c, III)

Atomic weight 58.69

Ni	g	3d ⁸ s ² (³ F ₄)	- 85.0	
	liq.			$F - 4.3^{1462}$
	c	I (?)		$T - 0.0^{1130}_{-II}$
	c	II		$T - 0.12^{360}_{-III}$
	c	III	0.000	
Ni*	g	3d ⁸ 4s (³ D ₃)	- 85.58	$E^* - 0.583$
	g	(³ D ₂)	- 87.51	$E^* - 2.505$
	g	3d ⁸ 4s ² (³ F ₃)	- 88.79	$E^* - 3.792$
	g	3d ⁸ 4s (³ D ₁)	- 89.88	$E^* - 4.878$
	g	3d ⁸ 4s ² (³ F ₂)	- 91.31	$E^* - 6.310$
	g	3d ⁸ 4s (¹ D ₂)	- 94.71	$E^* - 9.707$
	g	3d ¹⁰ (¹ S ₀)	-126.93	$E^* - 41.93$
Ni ⁺	g	3d ⁹ (² D _{5/2})	-261.7	$I^* - 175.30$
Ni ⁺ *	g	(² D _{3/2})	-266.0	$E^* - 4.290$
	g	3d ⁸ 4s (⁴ F _{9/2})	-285.6	$E^* - 23.89$
	g	(⁴ F _{7/2})	-288.3	$E^* - 26.56$
	g	(⁴ F _{5/2})	-290.5	$E^* - 28.80$
	g	(⁴ F _{3/2})	-292.1	$E^* - 30.56$
Ni ⁺⁺	g	3d ⁸ (³ F)	-681.6	$I^* - 418.$
	aq.		15.2	
NiO	c		58.4	
Ni(OH) ₂	c	ppt.	129.8	

Nickel

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Ni(OH) ₂	c	ppt.	163.2	
NiF ₂	c		157.5	
	aq.		171.4	
NiCl ₂	c		75.0	<i>S</i> 19.17 ₄₀₀
	800		94.23	
	400		94.17	
	200		94.06	
	100		93.86	
	50		93.55	
	20		92.48	
NiCl ₂ ·2H ₂ O	c		220.6	<i>S</i> 10.3 ₄₀₀
NiCl ₂ ·4H ₂ O	c		363.5	<i>D</i> - 13.5
NiCl ₂ ·6H ₂ O	c		505.6	<i>S</i> - 1.16 ₄₀₀
NiBr ₂	c		53.4	<i>S</i> 18.9
	aq.		72.4	
NiBr ₂ ·3H ₂ O	c		277.3	<i>S</i> 0.2
NiI ₂	c		22.4	<i>S</i> 19.4
	aq.		41.8	
NiS	c		20.4	
NiSO ₄	c		216.	
	200		231.1	
NiSO ₄ ·7H ₂ O	c		713.9	<i>S</i> - 4.25 ₄₀₀
NiS ₂ O ₆	aq.		295.5	
NiS ₂ O ₆ ·6H ₂ O	c		708.1	<i>S</i> - 2.42
NiSe	c		14.	<i>S</i> 101.2 _{bromine water}
NiTe	c		11.	
NiN ₄ ·H ₂ O	c		- 31.7	
Ni(NO ₃) ₂	c		101.5	<i>S</i> 11.8 ₂₈₀
	200		113.3	
	6		110.2	
Ni(NO ₃) ₂ ·6H ₂ O	c		531.0	<i>S</i> - 7.47 ₄₀₀
Ni(NO ₂) ₂ ·5NH ₃	c			<i>D</i> - 13.8
Ni(NO ₂) ₂ ·6NH ₃	c			<i>D</i> - 17.0
NiF ₂ ·H ₂ O·½NH ₃	c			
NiF ₂ ·H ₂ O·NH ₃	c			<i>D</i> - 12.8
NiF ₂ ·H ₂ O·5NH ₃	c			<i>D</i> - 11.5
NiCl ₂ ·NH ₃	c		107.8	<i>S</i> 17.8 _{HCl(aq.)}
NiCl ₂ ·2NH ₃	c		137.7	<i>S</i> 19.5 _{HCl(aq.)}
NiCl ₂ ·6NH ₃	c		239.1	<i>S</i> 44.3 _{HCl(aq.)}
Ni(ClO ₃) ₂ ·6NH ₃	c			<i>D</i> - 17.5
Ni(ClO ₄) ₂ ·6NH ₃	c			<i>D</i> - 19.1
NiBr ₂ ·NH ₃	c		85.2	<i>D</i> - 20.8
NiBr ₂ ·2NH ₃	c		116.6	<i>D</i> - 20.4
NiBr ₂ ·6NH ₃	c		221.7	<i>D</i> - 15.4
NiI ₂ ·2NH ₃	c		83.7	<i>D</i> - 19.7

Nickel

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
$\text{NiI}_2 \cdot 6\text{NH}_3$	c		191.2	<i>D</i> - 15.9
$\text{Ni}(\text{IO}_3)_2 \cdot 5\text{NH}_3$	c			<i>D</i> - 12.7
$\text{NiSO}_4 \cdot \frac{1}{2}\text{NH}_3$	c		234.	<i>D</i> - 25.
$\text{NiSO}_4 \cdot 2\text{NH}_3$	c		278.6	<i>D</i> - 18.8
$\text{NiSO}_4 \cdot 4\text{NH}_3$	c		333.4	<i>D</i> - 16.4
$\text{NiS}_2\text{O}_6 \cdot 5\text{NH}_3$	c			<i>D</i> - 15.0
$\text{NiSO}_4 \cdot 6\text{NH}_3$	c		384.7	<i>D</i> - 14.7
$\text{NiSO}_2\text{O}_6 \cdot 6\text{NH}_3$	c			<i>D</i> - 16.8
$\text{NiSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot 6\text{H}_2\text{O}$	c	~dihydrate		<i>D</i> - 15.4
$\text{NiS}_2\text{O}_6 \cdot 6\text{NH}_3$	c			<i>D</i> - 14.7
$\text{Ni}(\text{H}_2\text{PO}_3)_2 \cdot 6\text{NH}_3$	c			<i>D</i> - 13.3
NiC_2	c		- 9.2	
$\text{Ni}(\text{CO})_4$	liq.			<i>V</i> - 6.92 ⁴⁰
$\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2$	aq.	nickel acetate	251.1	
$\text{NiBr}_2 \cdot 3\text{CH}_3\text{OH}$	c		237.3	<i>D</i> - 12.7
$\text{Ni}(\text{CN})_2$	c	ppt.	-232.	
$\text{Ni}(\text{CN})_4^{--}$	aq.		- 80.4	
$\text{Ni}(\text{CHO}_2)_2 \cdot 4\text{NH}_3$	c	nickel formate ammine		<i>D</i> - 15.1
$\text{Ni}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 4\text{NH}_3$	c	nickel acetate ammine		<i>D</i> - 12.7
$\text{Ni}(\text{CNS})_2 \cdot 6\text{NH}_3$	c			<i>D</i> - 10.8
$2\text{NiI}_2 \cdot \text{PbI}_2$	c		85.2	<i>S</i> 40.2
$2\text{NiI}_2 \cdot \text{PbI}_2 \cdot 3\text{H}_2\text{O}$	c		341.7	<i>S</i> - 11.1
$\text{NiBr}_2 \cdot \text{HgBr}_2$	aq.		112.4	
$\text{NiBr}_2 \cdot 2\text{HgBr}_2$	aq.		150.0	

Cobalt

Atomic number 27 Standard state Co (c, III) Atomic weight 58.94

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Co	g	$3d^7 4s^2 (^4F_{9/2})$	- 85.	V - 74. ²³⁷⁵
	liq.			F - 3.95 ¹⁴⁸⁰
	c	I		T 0.12 ¹¹⁸⁰ → II
	c	II		T 0.06 ⁴⁶⁰ → III
	c	III	0.000	
Co*	g	$3d^7 4s^2 (^4F_{7/2})$	- 87.32	E^* - 2.32
	g	$(^4F_{5/2})$	- 89.00	E^* - 4.00
	g	$(^4F_{3/2})$	- 90.15	E^* - 5.15
	g	$3d^8 4s (^4F_{9/2})$	- 94.91	E^* - 9.91
	g	$(^4F_{7/2})$	- 97.36	E^* - 12.36
	g	$(^4F_{5/2})$	- 98.35	E^* - 13.35
	g	$(^4F_{3/2})$	- 99.45	E^* - 14.45
Co ⁺	g	$3d^8 (^3F_4)$	-266.0	I^* -179.6
	g	$(^3F_3)$	-268.7	E^* - 2.71
	g	$(^3F_2)$	-270.5	E^* - 4.55
Co ⁺⁺	g	$3d^7 (^4F)$	-866.0	I^* -399.
	aq.		16.5	
CoO	c		57.5	
Co ₃ O ₄	c		196.5	
Co(OH) ₂	c		131.5	
Co(OH) ₃	c		177.0	
CoF ₂	liq.			Q_f 161. ⁷⁰⁰
	aq.		172.8	
CoCl ₂	c		76.9	S 18.44 ⁴⁰⁰
	400		95.40	
CoCl ₂ ·2H ₂ O	c		222.3	S 9.85 ²³ ₄₀₀
CoCl ₂ ·6H ₂ O	c		508.5	S - 2.85 ⁴⁰⁰
CoBr ₂	c		55.0	S 18.4
	aq.		73.43	
CoBr ₂ ·6H ₂ O	c		484.9	S - 1.28
CoI ₂	c		24.2	S 18.8
	aq.		42.97	
CoS	c	ppt.	22.3	
Co ₂ S ₃	c		40.0	
CoSO ₄	c		216.7	
	400		231.7	
	200		231.6	
CoSO ₄ ·6H ₂ O	c		643.3	
CoSO ₄ ·7H ₂ O	c		713.9	S - 3.57 ⁸⁰⁰
CoSe	c		12.	S 74.0 _{bromine water}
CoTe	c		11.	S 115.9 _{bromine water}
Co(NO ₃) ₂	c		102.8	S 11.88 ⁸⁰⁰
	aq.		114.7	

Cobalt

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Co(NO ₃) ₂ ·6H ₂ O	c liq.		529.8	<i>S</i> — 4.96 ₄₀₀ <i>F</i> — 8.7 ⁶⁸
[Co(NH ₃) ₅ H ₂ O] ⁺⁺⁺	aq.		178.5	
[Co(NH ₃) ₅ NO ₃] ⁺⁺	aq.		158.7	
[Co(NH ₃) ₅ NO ₃](NO ₃) ₂	aq.		256.9	
	c		271.8	<i>S</i> — 14.90 ²⁵
[Co(NH ₃) ₅ H ₂ O](NO ₃) ₃	c aq.		341.1 325.7	<i>S</i> — 15.38 ²⁵
CoF ₂ ·H ₂ O·½NH ₃	c			
CoF ₂ ·H ₂ O·NH ₃	c			<i>D</i> — 12.5
CoF ₂ ·H ₂ O·5NH ₃	c			<i>D</i> — 10.5
CoCl ₂ ·NH ₃	c		109.2	<i>S</i> 17.5 _{HCl(aq.)}
CoCl ₂ ·2NH ₃	c	rose	138.8	<i>S</i> 19.6
[Co(NH ₃) ₅ Cl] ⁺⁺	aq.		146.5	
[Co(NH ₃) ₅ Cl]Cl ₂	c aq.		237.9 225.4	<i>S</i> — 12.42 ²⁵
CoCl ₂ ·6NH ₃	c		239.0	<i>S</i> 46.3
Co(NH ₃) ₆ Cl ₃	c	product unknown		<i>D</i> — 18.9
[Co(NH ₃) ₅ H ₂ O]Cl ₃	c aq.		302.4 295.9	<i>S</i> — 6.46
CoBr ₂ ·NH ₃	c		87.6	<i>D</i> — 21. ¹⁸⁵
CoBr ₂ ·2NH ₃	c		120.2	<i>D</i> — 21.7 ¹⁸⁵
CoBr ₂ ·2NH ₄ Br	aq.		193.9	
[Co(NH ₃) ₅ Br] ⁺⁺	aq.		137.2	
[Co(NH ₃) ₅ Br]Br ₂	c aq.		207.1 194.4	<i>S</i> — 12.66
CoBr ₂ ·6NH ₃	c		230.	<i>D</i> — 14.0 ¹³⁶
[Co(NH ₃) ₆ H ₂ O]Br ₃	c aq.		273.7 264.5	<i>S</i> — 9.25 ²⁵
CoI ₂ ·2NH ₃	c		85.9	<i>D</i> — 19.9 ¹⁴⁷
CoI ₂ ·6NH ₃	c		188.6	<i>D</i> — 14.7
CoSO ₄ ·½NH ₃	c		234.1	<i>D</i> — 24.
CoSO ₄ ·2NH ₃	c		279.7	<i>D</i> — 19.4
CoSO ₄ ·(NH ₄) ₂ SO ₄ ·6H ₂ O	c	-dihydrate		<i>D</i> — 14.8
CoSO ₄ ·3NH ₃	c		307.5	<i>D</i> — 16.8
CoSO ₄ ·4NH ₃	c		333.2	<i>D</i> — 14.78
CoSO ₄ ·6NH ₃	c		383.1	<i>D</i> — 13.98
Co ₂ C	c		11.3	
CoCO ₃	c	ppt.	172.8	
Co(C ₂ H ₃ SO ₄) ₂	aq.		432.3	
2CoI ₂ ·PbI ₂	c		84.3	<i>S</i> 41.5
2CoI ₂ ·PbI ₂ ·3H ₂ O	c		341.6	<i>S</i> — 10.6
CoBr ₂ ·HgBr ₂	4400		113.5	
CoBr ₂ ·2HgBr ₂	8400		151.	
2CoBr ₂ ·HgBr ₂	4800		189.1	

Iron

Atomic number 26

Standard State Fe (c, IV, α)

Atomic weight 55.84

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Fe	g	3d ⁶ 4s ² (⁵ D ₄)	- 94.	V - 76. ¹⁶⁰⁰
	liq.			F - 3.86 ¹³³⁵
	c	I, δ		T 0.11 ¹⁴⁰⁵ →II
	c	II, γ		T 0.21 ⁹⁰⁶ →III
	c	III, β		T 0.37 ³²⁵⁻⁷⁹⁵ →IV
Fe*	c	IV, α	0.000	
	g	3d ⁶ 4s ² (⁵ D ₃)	- 95.18	E^* - 1.18
	g	(⁵ D ₂)	- 96.00	E^* - 2.00
	g	(⁵ D ₁)	- 96.53	E^* - 2.53
	g	(⁵ D ₀)	- 96.78	E^* - 2.78
	g	3d ⁷ (⁴ F)4s (⁵ F ₄)	-113.72	E^* - 19.72
	g	(⁵ F ₄)	-115.00	E^* - 21.00
	g	(⁵ F ₃)	-116.00	E^* - 22.00
	g	(⁵ F ₂)	-116.73	E^* - 22.73
	g	(⁵ F ₁)	-117.21	E^* - 23.21
	g	(³ F ₄)	-128.09	E^* - 34.09
	g	(³ F ₃)	-129.76	E^* - 35.76
	g	(³ F ₂)	-130.92	E^* - 36.92
	g	3d ⁶ 4s (⁶ D _{5/2})	-276.0	I^* -180.6
	g	(⁶ D _{7/2})	-277.1	E^* - 1.12
	g	(⁶ D _{5/2})	-277.9	E^* - 1.90
	g	(⁶ D _{3/2})	-278.5	E^* - 2.46
	g	(⁶ D _{1/2})	-278.8	E^* - 2.78
	g	3d ⁷ (⁴ F _{9/2})	-281.4	E^* - 5.35
Fe ⁺ Fe ⁺ *	g	(⁴ F _{7/2})	-282.9	E^* - 6.92
	g	(⁴ F _{5/2})	-284.1	E^* - 8.08
	g	(⁴ F _{3/2})	-284.9	E^* - 8.87
	g	3d ⁶ (⁵ D)4s (⁴ D _{7/2})	-298.6	E^* - 22.65
	g	(⁴ D _{5/2})	-299.9	E^* - 23.89
	g	(⁴ D _{3/2})	-300.7	E^* - 24.71
	g	(⁴ D _{1/2})	-301.2	E^* - 25.18
	g	3d ⁶ (⁵ D)	-658.0	I^* -308.5
	aq.		20.6	
	aq.		9.3	
	c	I	64.3	
	c	II		T - 0.10 ⁻⁹⁰ →I
Fe ₂ O ₃ Fe ₃ O ₄	c		198.5	
	c	I		T 0.10 ⁷⁴⁰ →II
	c	II		T 0.58 ⁴⁸⁵ →III
	c	III	266.9	
	c	IV		T - 0.18 ⁻¹⁶⁰ →III
Fe(OH) ₂	c	ppt.	135.9	
Fe(OH) ₃	c	ppt.	197.3	
FeF ₂	1200		177.0	

Iron

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
FeF ₂	liq.			Q_f 158. ⁸⁰⁰
FeF ₃	liq.			Q_f 233. ⁷⁰⁰
	1200		243.3	
	150		242.5	
FeCl ₂	g		40.	V - 32.1 ⁸⁰⁰
	c		81.9	S 17.90 ₄₀₀
	400	(solution acid)	99.76	
FeCl ₂ ·2H ₂ O	c		227.8	S 8.7 ²⁰ ₃₀₀
FeCl ₂ ·4H ₂ O	c		370.5	S 2.75 ₄₀₀
FeCl ₃	c		96.4	S 31.7
	1000		128.1	
	200		127.1	
	100		126.1	
	50		123.1	
	20		102.8	
Fe ₂ Cl ₆	g		159.7	
	liq.			F - 21.8
FeCl ₃ ·2½H ₂ O	c		278.0	S 21.0 ₁₃₀₀
FeCl ₃ ·6H ₂ O	c		532.7	S 5.64 ²¹ ₁₂₀₀
FeOCl	c		97.1	
Fe(ClO ₃) ₂	aq.		67.4	
FeBr ₂	c		60.0	
	aq.		78.0	
FeBr ₃	aq.		95.2	
FeI ₂	c		24.2	S 23.3
	aq.		47.5	
FeI ₃	aq.		49.5	
FeS	liq.			F 2.8 ¹¹⁹⁵
	c		23.1	
FeS ₂	c	pyrite	35.5	
	c	marcasite	35.5	
FeSO ₄	c		221.3	S 14.90 ¹⁴ ₁₁₀
	400		235.98	
	200		235.94	
FeSO ₄ ·H ₂ O	c		297.0	S 7.54 ¹⁴ ₁₁₀
FeSO ₄ ·4H ₂ O	c		508.1	S 1.60 ¹⁴ ₁₁₀
FeSO ₄ ·7H ₂ O	c		719.0	S - 4.51 ₄₀₀
Fe ₂ (SO ₄) ₃	1200		653.2	
	400		653.0	
	300		652.8	
	150		652.2	
	50		648.2	
Fe(HSO ₄) ₃	600		695.1	
FeSe	c		13.2	
FeTe	c		8.	S 268.2 _{bromine water}

Iron

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Fe_4N	c		— 1.1	
$FeNO^{--}$	aq.		9.6	
$Fe(NO_3)_2$	aq.		118.8	
$Fe(NO_3)_3$	800		156.3	
	200		157.4	
$Fe(NO_3)_3 \cdot 9H_2O$	c		780.7	$S - 9.1$
$FeF_2 \cdot H_2O \cdot \frac{1}{2}NH_3$	c			
$FeF_2 \cdot H_2O \cdot NH_3$	c			$D - 12.4$
$FeF_2 \cdot H_2O \cdot 5NH_3$	c			$D - 9.8$
$FeNOCl_2$	aq.		88.9	
$FeCl_2 \cdot NH_3$	c		113.6	$D - 20.76$
$FeCl_2 \cdot 2NH_3$	c		144.1	$D - 19.48$
$FeCl_2 \cdot 6NH_3$	c		246.6	$D - 14.66$
$FeCl_2 \cdot 10NH_3$	c		319.5	$D - 7.25$
$FeBr_2 \cdot NH_3$	c		91.8	$D - 20.78$
$FeBr_2 \cdot 2NH_3$	c		122.6	$D - 19.87$
$FeBr_2 \cdot 6NH_3$	c		219.8	$D - 13.34$
$FeBr_3 \cdot 6NH_3$	c			$D - 11.2$
$FeI_2 \cdot 2NH_3$	c		87.1	$D - 20.46$
$FeI_2 \cdot 6NH_3$	c		188.9	$D - 14.50$
$FeNOSO_4$	aq.		224.8	
$NH_4Fe(SO_4)_2$	aq.		466.2	
$NH_4Fe(SO_4)_2 \cdot 12H_2O$	c		1303.3	$S - 16.6$
$FeSO_4 \cdot NH_3$	c		252.8	$D - 20.5^{900}$
$FeSO_4 \cdot 2NH_3$	c		281.6	$D - 17.9$
$(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$	c		935.0	$S - 9.8$
$FeSO_4 \cdot 3NH_3$	c		306.7	$D - 14.1^{121}$
$FeSO_4 \cdot 4NH_3$	c		331.3	$D - 13.6^{110}$
$FeSO_4 \cdot 6NH_3$	c		378.6	$D - 12.7^{83}$
Fe_3C	c		— 5.2	
$FeCO_3$	c		172.8	
$Fe(CO)_5$	g		180.0	
	liq.		189.8	
	c			$F - 3.25^{-20}$
$Fe_2(C_2O_4)_3$	300	ferric oxalate	610.1	
	100		610.4	
$Fe(HC_2O_4)_3$	aq.	ferric bioxalate	597.3	
$Fe(C_2H_3O_2)_3$	1800	ferric acetate	357.1	
	600		358.3	
	300		358.6	
$Fe(CN)_6^{---}$	aq.		— 146.7	
$Fe(CN)_6^{----}$	aq.		— 121.6	
$Fe_4(Fe(CN)_6)_3$	c		— 319.	
$FeCO(CN)_5^{---}$	aq.		— 42.9	
$HFe(CN)_5^{--}$	aq.		— 146.6	

Iron

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
HFe(CN) ₅ ---	aq.		-121.7	
H ₂ Fe(CN) ₅ -	aq.		-147.4	
H ₂ Fe(CN) ₅ ---	aq.		-121.9	
H ₃ Fe(CN) ₅ -	aq.		-122.2	
H ₃ Fe(CN) ₅	aq.		-148.2	
H ₄ Fe(CN) ₅	c		-122.9	<i>S</i> 0.4 ¹⁰ ₂₀₀
	aq.		-122.3	
(NH ₄) ₄ Fe(CN) ₆	aq.		4.2	
(NH ₄) ₄ Fe(CN) ₆ ·3H ₂ O	c		216.1	<i>S</i> - 6.8 ¹⁴
H ₃ FeCO(CN) ₅	aq.		- 43.3	
H ₃ FeCO(CN) ₅ ·H ₂ O	c		19.9	<i>C</i> 808.3
Fe ₃ Si	c		- 20.	
FeSiO ₃	c		273.5	
2FeI ₂ ·PbI ₂	c		90.0	<i>S</i> 46.9
2FeI ₂ ·PbI ₂ ·3H ₂ O	c		352.2	<i>S</i> - 10.2
Zn ₂ Fe(CN) ₆	c		- 40.0	

Manganese

Atomic number 25

Standard state Mn (c, III)

Atomic weight 54.93

Mn	g	3d ⁵ 4s ² (⁶ S _{5/2})	- 74.	
	liq.			<i>F</i> - 3.6 ¹²⁶⁰
	c	I		<i>T</i> 0.25 ¹⁰⁴⁴ →II
	c	II		<i>T</i> 0.16→III
	c	III	0.000	
Mn*	g	3d ⁶ (⁵ D)4s (⁶ D _{9/2})	-121.98	<i>E</i> * - 47.98
	g	(⁶ D _{7/2})	-122.60	<i>E</i> * - 48.60
	g	(⁶ D _{5/2})	-123.01	<i>E</i> * - 49.01
	g	(⁶ D _{3/2})	-123.45	<i>E</i> * - 49.45
	g	(⁶ D _{1/2})	-123.64	<i>E</i> * - 49.64
	g	3d ⁵ 4s(⁷ S)4p (⁸ P ¹ _{9/2})	-143.97	<i>E</i> * - 69.97
	g	(⁸ P ¹ _{7/2})	-144.00	<i>E</i> * - 69.00
	g	(⁸ P ¹ _{5/2})	-144.04	<i>E</i> * - 69.04
Mn ⁺	g	3d(⁶ S)4s (⁷ S ₂)	-246.08	<i>I</i> * - 170.63
Mn ⁺⁺	g	3d ⁵ (⁶ S _{5/2})	-607.5	<i>I</i> * - 361.0
	aq.		49.2	
Mn ⁺⁺⁺	aq.		25.	
MnO	c	I	96.5	
	c	II		<i>T</i> - 0.15 ⁻⁶⁰ →I
MnO ₂	c	I	123.	
	c	ppt.	115.5	
	c	II		<i>T</i> - 0.08 ⁻¹⁸⁰ →I

Manganese

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
MnO ₄ ⁻	aq.		122.3	
Mn ₂ O ₃	c		233.	
Mn ₃ O ₄	c		345.0	
HMnO ₄	aq.		122.3	
Mn(OH) ₂	c	ppt.	163.4	
Mn(OH) ₃	c	ppt.	221.	
MnF ₂	1200		205.9	
MnF ₃	aq.		260.	
MnF ₃ ·3HF	aq.		486.8	
MnCl ₂	c		112.7	<i>S</i> 16.00 ₃₀₀
	100		128.3	
	400		128.7	
MnCl ₂ ·2H ₂ O	c		257.2	<i>S</i> 8.20 ₃₀₀
MnCl ₂ ·4H ₂ O	c		400.7	<i>S</i> 1.54 ₄₀₀
H ₂ MnCl ₆	aq.		215.	
MnBr ₂	c		91.	
	aq.		106.	
MnBr ₂ ·H ₂ O	c		160.0	<i>D</i> - 11.2
MnBr ₂ ·4H ₂ O	c		363.4	<i>D</i> - 10.0
MnBr ₃	aq.		109.0	
MnI ₂	c		49.8	<i>S</i> 26.2
	aq.		76.0	
MnI ₂ ·H ₂ O	c		120.2	<i>D</i> - 12.6
MnI ₂ ·2H ₂ O	c		190.0	<i>D</i> - 12.0
MnI ₂ ·4H ₂ O	c		329.6	<i>D</i> - 12.0
MnI ₂ ·6H ₂ O	c		465.	<i>D</i> - 10.0
MnS	c	ppt.	47.0	
MnSO ₄	c		251.2	<i>S</i> 13.80 ₄₀₀
	400		265.0	
	200		264.97	
	100		264.90	
	50		264.72	
	20		264.19	
MnSO ₄ ·H ₂ O	c		321.5	<i>S</i> 7.80 ₄₀₀
MnSO ₄ ·6H ₂ O	c		602.9	<i>S</i> 0.04 ₄₀₀
MnSO ₄ ·7H ₂ O	c		745.3	
MnS ₂ O ₆	aq.		329.4	
MnS ₂ O ₆ ·6H ₂ O	c		741.5	<i>S</i> - 1.93 ₄₀₀
Mn ₂ (SO ₄) ₃	c		635.	<i>S</i> 32.1
	aq.		657.	
MnSe	c		26.3	
MnN ₂	c		- 94.0	
Mn ₃ N ₄	c		56.6	<i>S</i> 273.4H ₂ SO ₄ (50)
Mn(NO ₃) ₂	c		134.9	<i>S</i> 12.93 ₂₈₀
	400		147.8	

Manganese

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Mn(NO ₃) ₂	6		145.7	
	3		145.1	
Mn(NO ₃) ₂ ·3H ₂ O	c		356.8	F — 5.6 ³⁵
Mn(NO ₃) ₂ ·6H ₂ O	c		564.2	S — 6.15 ₄₀₀
	liq.		555.9	F — 8.26 ³⁶
MnF ₂ ·H ₂ O·½NH ₃	c			
MnF ₂ ·H ₂ O·NH ₃	c			D — 12.2
MnF ₂ ·H ₂ O·5NH ₃	c			D — 9.8
MnCl ₂ ·NH ₃	c		145.3	D — 21.7
MnCl ₂ ·2NH ₃	c		175.1	D — 18.8
MnCl ₂ ·2NH ₄ Cl·2H ₂ O	c		413.5	S — 5.70
MnCl ₂ ·6NH ₃	c		268.9	D — 12.6
MnBr ₂ ·NH ₃	c		123.7	D — 21.95
MnBr ₂ ·2NH ₃	c		155.1	D — 20.4
MnBr ₂ ·2NH ₄ Br	400		226.34	
MnBr ₂ ·6NH ₃	c		256.1	D — 14.3
MnI ₂ ·2NH ₃	c		93.4	D — 21.7
MnI ₂ ·6NH ₃	c		201.8	D — 16.15
MnSO ₄ ·½NH ₃	c		262.5	D — 19.7
MnSO ₄ ·NH ₃	c		276.6	D — 17.3
MnSO ₄ ·2NH ₃	c		304.8	D — 17.2
MnSO ₄ ·(NH ₄) ₂ SO ₄ ·2H ₂ O	c		688.1	
MnSO ₄ ·(NH ₄) ₂ SO ₄ ·6H ₂ O	c		964.0	S — 9.7
MnSO ₄ ·5NH ₃	c		374.8	D — 12.4
MnSO ₄ ·6NH ₃	c		397.5	D — 11.7
Mn ₂ (PO ₄) ₃	c	ppt.	736.	
Mn ₃ C	c		23.	
MnCO ₃	c		218.	
	c	ppt.	207.8	
MnC ₂ O ₄	c	manganese oxalate	241.8	S 2.73 _{HNO₃(9)}
MnC ₂ O ₄ ·2H ₂ O	c		384.7	S — 3.50 _{HNO₃(9)}
MnC ₂ O ₄ ·3H ₂ O	c		454.7	S — 5.06 _{HNO₃(9)}
Mn(CHO ₂) ₂	c	manganese formate	244.1	S 4.3 ³⁴ ₄₀₀
	aq.		248.4	
Mn(CHO ₂) ₂ ·2H ₂ O	c		388.0	S 2.9 ³⁴ ₄₀₀
Mn(C ₂ H ₃ O ₂) ₂	c	manganese acetate	272.0	S 12.2 ³⁷ ₄₀₀
	aq.		284.2	
Mn(C ₂ H ₃ O ₂) ₂ ·4H ₂ O	c		556.1	S 1.6 ³⁸ ₄₀₀
MnSiO ₃	gls.		292.8	S 61.6 _{HF(4.44)}
	c		301.3	S 53.1 _{HF(4.44)}
MnBr ₂ ·2HgBr ₂	aq.		183.9	
MnBr ₂ ·HgBr ₂	aq.		146.2	
2MnBr ₂ ·HgBr ₂	aq.		255.1	
2MnI ₂ ·PbI ₂	c		150.0	S 43.9 ¹⁵
2MnI ₂ ·PbI ₂ ·3H ₂ O	c		407.5	S — 8.5 ¹⁶

Chromium

Atomic number 24

Standard state Cr (c)

Atomic weight 52.01

Formula	State	Description	Q_f , kcal, mole ⁻¹	Q , kcal. mole ⁻¹
Cr	g	3d ⁵ (⁶ S)4s (⁷ S ₃)	— 88.	
	liq.			F — 3.65 ¹⁸⁰⁰
	c		0.000	
Cr*	g	3d ⁵ (⁶ S)4s (⁶ S ₂)	— 109.62	E^* — 21.62
	g	3d ⁴ 4s ² (⁶ D ₀)	— 110.06	E^* — 22.06
	g	(⁶ D ₁)	— 110.24	E^* — 22.24
	g	(⁶ D ₂)	— 110.57	E^* — 22.57
	g	(⁶ D ₃)	— 111.05	E^* — 23.05
	g	(⁶ D ₄)	— 111.64	E^* — 23.64
Cr ⁺	g	3d ⁵ (⁶ D _{7/2})	— 244.7	I^* — 155.27
Cr ⁺ *	g	3d ⁴ 4s (⁶ D _{1/2})	— 278.8	E^* — 34.06
	g	(⁶ D _{3/2})	— 279.0	E^* — 34.26
	g	(⁶ D _{5/2})	— 279.3	E^* — 34.59
	g	(⁶ D _{7/2})	— 279.7	E^* — 35.03
	g	(⁶ D _{9/2})	— 280.3	E^* — 35.58
Cr ⁺⁺	g	3d ⁴ (⁶ D)	— 629.	I^* — 382.
Cr ⁺⁺ *	g	(³ F ₂)	— 683.	E^* — 54.1
	g	(³ F ₃)	— 683.1	E^* — 54.2
	g	(³ F ₄)	— 683.4	E^* — 54.5
[Cr] ⁺⁺	aq.		42.8	
Cr ⁺⁺⁺	g	3d ³ (⁴ F)	— 1255.	I^* — 635.
[Cr] ⁺⁺⁺	aq.		64.6	
Cr ⁺⁺⁺ *	g	3d ³ (² G)	— 1298.	E^* — 42.7
Cr ⁺⁺⁺⁺	g	3d ² (³ F)	— 2461.	I^* — 1162.
Cr ⁺⁺⁺⁺⁺	g	3d (² D)	— 4132.	I^* — 1670.
CrO	g		— 59.	D^* — 87.2
CrO ₂	c		139.3	
	80		141.8	
	50		141.75	
	25		141.65	
	10		141.10	
	4		140.66	
	3.3		140.32	
CrO ₄ --	aq.		207.9	
Cr ₂ O ₃	c		273.	
Cr ₂ O ₇ --	aq.		350.4	
Cr ₃ O ₁₀ ---	aq.		494.	
Cr ₇ H ₂	c		— 3.7	
CrO·OH	c		180.	
[CrOH] ⁺⁺	aq.		102.7	
H ₂ CrO ₄	aq.		210.2	
[Cr](OH) ₃	c	ppt.	249.3	
[CrOH](OH) ₂	c	ppt.	245.1	
[Cr(OH) ₂]OH	c	ppt.	241.0	

Chromium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹	
Cr ₂ O ₃ ·2H ₂ O	c		439.		
CrF ₂	c		152.		
CrF ₃	c		231.		
[Cr]F ₃	aq.		296.6		
H ₃ [Cr]F ₆	aq.		531.2		
CrCl ₂	c		103.1	S	18.6
	aq.		121.7		
CrCl ₂ ·3H ₂ O	c	light green	321.5	S	5.3
CrCl ₂ ·4H ₂ O	c	dark green	392.2	S	2.0
[CrCl ₂] ⁺	aq.		134.1		
[CrCl ₂]Cl	c	rose	143.0	S	30.6
	aq.	green	173.6		
[Cr]Cl ₃	aq.	purple	183.0		
[Cr(H ₂ O) ₄ Cl ₂]Cl	c	green	438.7	S	8.4
[Cr(H ₂ O) ₄ Cl ₂]Cl·2H ₂ O	c	green	583.9	S	— 0.04 ₁₅₀
[Cr(H ₂ O) ₆]Cl ₃	c	purple	581.2	S	12.0
[Cr(H ₂ O) ₄ Cl ₂]Cl·6H ₂ O	c	green	857.2	S	0.0
CrO ₂ Cl ₂	g		126.1	V	— 8.5
	liq.		134.6	S	16.6
[CrOH]Cl ₂	aq.		181.6		
[Cr(OH) ₂]Cl	aq.		194.4		
[CrBr ₂]Br	aq.		138.4		
[Cr]Br ₃	aq.		149.9		
[CrBr ₂ (H ₂ O) ₄]Br·2H ₂ O	c	green	548.0	S	0.68
[Cr(H ₂ O) ₆]Br ₃	c	purple	545.8	S	14.35
CrI ₂	c		63.7	S	5.72
	aq.		69.4		
[CrSO ₄] ⁺	aq.		266.4		
Cr ₂ (SO ₄) ₃	aq.	"modified," hydro- lyzed to form [Cr ₂ (SO ₄) ₂](OH) ₂	753.4		
[Cr ₂ (SO ₄) ₃]	aq.		757.4		
[Cr ₂ (SO ₄) ₂]SO ₄	aq.	green	760.9		
[Cr ₂ SO ₄](SO ₄) ₂	aq.	green	767.8		
[Cr] ₂ (SO ₄) ₃	aq.	purple	772.3		
Cr ₂ (SO ₄) ₃ ·6H ₂ O	c	green	1282.2	S	13.4
[Cr(H ₂ O) ₆] ₂ (SO ₄) ₃ ·2H ₂ O	c	purple	1707.9	S	10.18
[Cr(H ₂ O) ₆] ₂ (SO ₄) ₃ ·3H ₂ O	c	purple	1777.7	S	8.3
[Cr(H ₂ O) ₆] ₂ (SO ₄) ₃ ·5H ₂ O	c	purple	1917.0	S	6.3
CrN	c		29.5		
(NH ₄) ₂ CrO ₄	c		276.9	S	— 5.8 ₈₀₀
	aq.		271.1		
(NH ₄) ₂ Cr ₂ O ₇	c		423.6	S	— 12.90 ₁₆ ₃₄₀
	600		410.7		
CrCl ₂ ·3NH ₃	c		175.2	D	— 13.1

Chromium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CrCl ₂ ·6NH ₃	c		241.4	D — 11.1
Cr ₃ C ₂	c		140.	
PbCrO ₄	c		221.4	
2CrI ₂ ·PbI ₂	c		160.2	S — 20.4
2CrI ₂ ·PbI ₂ ·3H ₂ O	c		388.0	S — 2.3

Molybdenum

Atomic number 42

Standard state Mo (c)

Atomic weight 96.0

Mo	g	4d ⁵ (⁶ S)5s(⁷ S ₃)	— 160.	
	c		0.000	
Mo*	g	4d ⁵ (⁶ S)5s(⁶ S ₂)	— 190.65	E^* — 30.65
	g	4d ⁴ 5s ² (⁶ D ₀)	— 191.22	E^* — 31.22
	g	(⁶ D ₁)	— 191.72	E^* — 31.72
	g	(⁶ D ₂)	— 192.61	E^* — 32.61
	g	(⁶ D ₃)	— 193.74	E^* — 33.74
	g	(⁶ D ₄)	— 195.15	E^* — 35.15
Mo ⁺	g	4d ⁴ (⁶ D)5s(⁶ D)	— 331.	I^* — 169.56
MoO ₂	c		130.	
MoO ₃	c		176.5	
	aq.		178.0	
MoO ₄	aq.		163.4	
MoO ₄ [—]	aq.		243.5	
MoO ₅	aq.		145.0	
H ₂ MoO ₄	c	MoO ₃ ·H ₂ O	247.0	D — 18.76
	aq.		246.4	
H ₂ MoO ₄ ·H ₂ O	c	MoO ₃ ·2H ₂ O	319.4	D — 14.70
MoF ₆	c			V — 8.30 ^{17,5}
	liq.			F — 2.1
PbMoO ₄	c		262.1	D — 33.1
CuMoO ₄	c		241.5	D — 26.5
FeMoO ₄	c		254.3	D — 13.5
Fe ₂ (MoO ₄) ₃ ·xH ₂ O	c		698.7+68.37x	

Tungsten

Atomic number 74

Standard state W (c)

Atomic weight 184.0

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal, mole ⁻¹
W	g	5d ⁴ 6s ² (⁵ D ₀)	- 210.	
	c		0.000	
W*	g	5d ⁴ 6s ² (⁵ D ₁)	- 214.75	$E^* - 4.75$
	g	(⁵ D ₂)	- 219.47	$E^* - 9.47$
	g	(⁵ D ₃)	- 223.75	$E^* - 13.75$
	g	(⁵ D ₄)	- 227.71	$E^* - 17.71$
	g	5d ⁵ 6s (⁷ S ₃)	- 218.40	$E^* - 8.40$
WO ₂	c		130.5	
WO ₃	c		195.7	
WO ₄ --	aq.		266.3	
W ₂ O ₅	c		324.	
H ₂ WO ₄	c		284.5	
	aq.		284.4	
WO ₃ ·H ₂ O ₂	aq.		331.0	
WO ₃ ·2H ₂ O ₂	aq.		377.2	
WO ₃ ·3H ₂ O ₂	aq.		424.6	
WF ₆	liq.			$V - 6.25$
	c			$V_s - 8.72^a$
WS ₂	c		84.	
CuWO ₄	c		246.3	
CuWO ₄ ·2H ₂ O	c		389.9	
FeWO ₄	c		269.7	
FeWO ₄ ·3H ₂ O	c		482.3	
Fe ₂ (WO ₄) ₃ ·8H ₂ O	c		1339.8	

Uranium

Atomic number 92

Standard state U (c)

Atomic weight 238.14

Formula	State	Description	Q_f , <i>kcal. mole</i> ⁻¹	Q , <i>kcal. mole</i> ⁻¹
U	g		- 220.	
	c		0.000	
UO ₂	c		256.6	
UO ₂ ⁺⁺	aq.		243.	
UO ₃	c		291.6	
U ₃ O ₈	c		845.2	
UO ₂ · $\frac{1}{2}$ H ₂ O	c		325.9	
UO ₂ ·H ₂ O	c		364.9	<i>S</i> 14.85 _{HNO₃ (110)}
UO ₂ · $1\frac{1}{2}$ H ₂ O	c		401.1	
UO ₂ ·2H ₂ O	c		435.8	<i>S</i> 12.38 _{HNO₃ (110)}
UO ₄ ·2H ₂ O	c		426.0	<i>S</i> 0.1 _{H₂SO₄ (100)}
JF ₆	liq.			<i>V</i> -10.4 ⁴²
UCl ₃	c		213.	
UCl ₄	c		251.	
UO ₂ Cl ₂	aq.		321.8	
UO ₂ Cl ₂ ·H ₂ O	c		384.0	<i>S</i> 6.0 ₁₀₀₀
UO ₂ Br ₂	aq.		300.	
UO ₂ SO ₄	c		427.	
	aq.		455.0	
UO ₂ SO ₄ ·3H ₂ O	c		655.6	<i>S</i> 5.1 ₁₀₀₀
U(SO ₄) ₂	c		428.	
U ₃ N ₄	c		274.	
UO ₂ (NO ₃) ₂	c		322.2	<i>S</i> 19.0 ¹² ₂₂₀
	aq.		341.2	
UO ₂ (NO ₃) ₂ ·H ₂ O	c		397.7	<i>S</i> 11.87 ₂₂₀
UO ₂ (NO ₃) ₂ ·2H ₂ O	c		473.0	<i>S</i> 5.05 ¹² ₂₂₀
UO ₂ (NO ₃) ₂ ·3H ₂ O	c		544.4	<i>S</i> 1.85 ¹² ₂₂₀
UO ₂ (NO ₃) ₂ ·6H ₂ O	c		756.8	<i>S</i> - 5.45 ¹² ₂₂₀
UC ₃	c		29.	
UO ₂ (C ₂ H ₃ O ₂) ₂	aq.		479.1	
UO ₂ (C ₂ H ₃ O ₂) ₂ ·2H ₂ O	c		620.2	<i>S</i> - 4.3 ₁₀₀₀
UO ₂ (C ₂ H ₃ O ₂) ₂ ·NH ₄ C ₂ H ₃ O ₂ ·6H ₂ O	c		1042.3	<i>S</i> - 3.8 ₁₀₀₀
UO ₂ CrO ₄	aq.		450.5	
UO ₂ CrO ₄ · $5\frac{1}{2}$ H ₂ O	c		832.8	<i>S</i> - 6.3 ₁₀₀₀

Vanadium

Atomic number 23

Standard state V (c)

Atomic weight 50.95

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
V	g	3d ³ 4s ² (⁴ F _{3/2})	— 85.	
	c		0.000	
V*	g	3d ³ 4s ² (⁴ F _{5/2})	— 85.39	E^* — 0.391
	g	(⁴ F _{7/2})	— 85.92	E^* — 0.921
	g	(⁴ F _{9/2})	— 86.57	E^* — 1.574
	g	3d ⁴ (⁵ D)4s (⁵ D _{1/2})	— 91.01	E^* — 6.013
	g	(⁵ D _{3/2})	— 91.13	E^* — 6.130
	g	(⁵ D _{5/2})	— 91.32	E^* — 6.320
	g	(⁵ D _{7/2})	— 91.58	E^* — 6.580
	g	(⁵ D _{9/2})	— 91.90	E^* — 6.903
V+	g	3d ⁴ (⁵ D ₀)	— 242.1	I^* — 155.7
V+ *	g	(⁵ D ₁)	— 242.2	E^* — 0.103
	g	(⁵ D ₂)	— 242.4	E^* — 0.304
	g	(⁵ D ₃)	— 242.7	E^* — 0.594
	g	(⁵ D ₄)	— 243.1	E^* — 0.966
	g	3d ³ (⁴ F)4s (⁵ F ₁)	— 249.5	E^* — 7.415
	g	(⁵ F ₂)	— 249.8	E^* — 7.649
	g	(⁵ F ₃)	— 250.1	E^* — 7.995
	g	(⁵ F ₄)	— 250.6	E^* — 8.501
	g	(⁵ F ₅)	— 251.1	E^* — 9.003
V++	g	3d ³ (⁴ F _{3/2})	— 579.8	I^* — 326.2
V++ *	g	(⁴ F _{5/2})	— 580.2	E^* — 0.413
	g	(⁴ F _{7/2})	— 580.7	E^* — 0.965
	g	(⁴ F _{9/2})	— 581.5	E^* — 1.66
V+++	g	3d ² (³ F ₂)	— 1190.	I^* — 609.
V+++ *	g	(³ F ₃)	— 1190.9	E^* — 0.91
	g	(³ F ₄)	— 1192.1	E^* — 2.07
V++++	g	3d (² D _{3/2})	— 2303.	I^* — 1113.
V++++ *	g	(² D _{5/2})	— 2304.8	E^* — 1.76
V+++++	g	3s ² (¹ S ₀)	— 3785.	I^* — 1480.
VO ₃ ⁻	aq.		257.6	
VO ₄ ⁻	aq.		243.9	
VO ₅ ⁻	aq.		229.9	
V ₂ O ₂	c		195.	
V ₂ O ₃	c		330.	
V ₂ O ₄	c		383.	
V ₂ O ₅	c		437.	
VCl ₂	c		147.	
VCl ₃	liq.		187.	
VCl ₄	liq.		165.	
VOCl ₃	c		200.	
NH ₄ VO ₃	c		283.5	S 6.15 ¹⁸ NaOH (aq.)

Columbium

Atomic number 41

Standard state Cb (c)

Atomic weight 93.3

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Cb	c		0.000	
Cb ₂ O ₅	c		442.	

Tantalum

Atomic number 73

Standard state Ta (c)

Atomic weight 181.4

Ta	c		0.000	
Ta ₂ O ₅	c		499.	

Protoactinium

Atomic number 91

Standard state Pa (c)

Atomic weight (232?)

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Titanium

Atomic number 22

Standard state Ti (c)

Atomic weight 47.90

Ti	g	3d ² 4s ² (³ F ₂)	- 100.	
	c		0.000	
Ti*	g	(³ F ₃)	- 100.48	E° - 0.484
	g	(³ F ₄)	- 101.10	E° - 1.101
	g	3d ³ (⁴ F)4s (⁶ F ₁)	- 118.66	E° - 18.660
	g	(⁶ F ₂)	- 118.79	E° - 18.785
	g	(⁶ F ₃)	- 118.96	E° - 18.963
	g	(⁶ F ₄)	- 119.20	E° - 19.195
	g	(⁶ F ₅)	- 119.48	E° - 19.480
	g	3d ² 4s ² (¹ D ₂)	- 120.65	E° - 20.65
	g	(³ P ₀)	- 124.02	E° - 24.02
	g	(³ P ₁)	- 124.18	E° - 24.18
	g	(³ P ₂)	- 124.49	E° - 24.49
Ti+	g	3d ² 4s (⁴ F _{3/2})	- 258.5	I° - 156.97
Ti+ *	g	(⁴ F _{5/2})	- 258.8	E° - 0.267
	g	(⁴ F _{7/2})	- 259.1	E° - 0.692
	g	(⁴ F _{9/2})	- 259.6	E° - 1.119
	g	3d ³ (⁴ F _{3/2})	- 261.1	E° - 2.585
	g	(⁴ F _{5/2})	- 261.3	E° - 2.801
	g	(⁴ F _{7/2})	- 261.6	E° - 3.095
	g	(⁴ F _{9/2})	- 262.0	E° - 3.461
Ti++	g	3d ² (³ F ₂)	- 573.1	I° - 313.1
Ti++ *	g	(³ F ₃)	- 573.6	E° - 0.523
	g	(³ F ₄)	- 574.3	E° - 1.201
Ti+++	g	3d (² D _{3/2})	1221.	I° - 645.
Ti+++ *	g	(² D _{5/2})	1222.1	E° - 1.091

Titanium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	$Q, kcal. mole^{-1}$
Ti ⁺⁺⁺⁺	g	3s ² 3p ⁶ (¹ S ₀)	2215.5	$I^{\circ} - 993.0$
TiO ₂	c	rutile I		$T \quad 0.75^{778} \rightarrow II$
	c	rutile II		$T \quad 0.30^{840} \rightarrow III$
	c	rutile III	218.0	
	c	anatase I		$T \quad 0.38^{785} \rightarrow II$
	c	anatase II		$T \quad 0.26^{800} \rightarrow III$
	c	anatase III		
	amorp.		214.1	
	amorp.	hydrated ppt.	210.0	
TiF ₆ ⁻⁻	aq.		557.5	
H ₂ TiF ₆	aq.		558.4	
TiCl ₃	c	brown		$S \quad 48.6$
	c	violet		$S \quad 45.8$
TiCl ₄	g		172.4	$V - 8.62^{136}$
	liq.		181.4	$S \quad 57.86_{2000}$
	c			$F - 2.23^{-80}$
	aq.	hydrolyzed	239.3	
TiCl ₄ ·H ₂ S	c		195.6	$D - 8.86$
TiCl ₄ ·2H ₂ S	c		208.3	$D - 7.49$
TiBr ₄ ·H ₂ S	c			$D - 8.57$
TiBr ₄ ·2H ₂ S	c			$D - 7.20$
TiCl ₄ ·PH ₃	c		202.4	
TiCl ₄ ·2PH ₃	c		215.5	$D - 10.8$
TiBr ₄ ·PH ₃	c			$D - 16.0$
TiBr ₄ ·2PH ₃	c			$D - 11.8$
TiC	c		110.	

Zirconium

Atomic number 40		Standard state	Zr (c)	Atomic weight 91.22
Zr	g	4d ² 5s ² (³ F ₂)	- 110.	
	c		0.000	
Zr*	g	(³ F ₃)	- 111.62	$E^{\circ} - 1.62$
	g	(³ F ₄)	- 113.53	$E^{\circ} - 3.53$
	g	(³ P ₀)	- 121.94	$E^{\circ} - 11.94$
	g	(³ P ₁)	- 122.46	$E^{\circ} - 12.46$
	g	(³ P ₂)	- 121.91	$E^{\circ} - 11.91$
	g	4d ³ (⁴ F)5s (⁵ F ₁)	- 123.86	$E^{\circ} - 13.86$
	g	(⁵ F ₂)	- 124.30	$E^{\circ} - 14.30$
	g	(⁵ F ₃)	- 124.92	$E^{\circ} - 14.92$
	g	(⁵ F ₄)	- 125.77	$E^{\circ} - 15.77$
	g	(⁵ F ₆)	- 126.76	$E^{\circ} - 16.76$
	g	4d ² (³ F)5s (⁴ F _{3/2})	- 270.0	$I^{\circ} - 159.6$
	g	(⁴ F _{5/2})	- 270.9	$E^{\circ} - 0.896$

Zirconium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	$Q, kcal. mole^{-1}$
Zr ⁺	g	(⁴ F _{7/2})	- 272.2	E° - 2.17
	g	(⁴ F _{5/2})	- 273.8	E° - 3.77
	g	4d ³ (⁴ F _{3/2})	- 277.3	E° - 7.32
	g	(⁴ F _{5/2})	- 278.2	E° - 8.24
	g	(⁴ F _{7/2})	- 279.4	E° - 9.39
	g	(⁴ F _{9/2})	- 280.7	E° - 10.70
Zr ⁺⁺	g	4d ² (³ F ₂)	- 594.	I° - 322.
Zr ⁺⁺⁺	g	4d (² D _{3/2})	- 1148.	I° - 553.
Zr ⁺⁺⁺⁺	g	4p ⁶ (¹ S ₀)	- 1930.	I° - 780.2
ZrO ⁺⁺	aq.		198.3	
ZrO ₂	c	monoclinic	258.1	
	c	ppt.	253.	
ZrO(OH) ₂	c		337.	
Zr(OH) ₄	c		411.0	
Zr(OH) ₄ ·H ₂ O	c		482.7	
Zr(OH) ₄ ·2H ₂ O	c		544.0	
ZrCl ₄	g		242.	V - 26.0 ⁸³⁹
	c		268.9	
ZrOCl ₂	aq.		272.5	
ZrOCl ₂ ·2H ₂ O	c		393.2	S 16.0
ZrOCl ₂ ·3½H ₂ O	c		502.8	S 9.0
ZrOCl ₂ ·6H ₂ O	c		683.0	S 0.7
ZrOCl ₂ ·8H ₂ O	c		822.5	S - 3.0
ZrBr ₄	c			V_s - 26.5 ⁸⁵⁶
ZrOBr ₂	aq.		250.6	
ZrOBr ₂ ·3½H ₂ O	c		480.9	S 9.01
ZrOBr ₂ ·8H ₂ O	c		799.6	S 2.01
ZrI ₄	c			V_s - 29.5 ⁴³¹
ZrOSO ₄	aq.		409.1	
ZrOSO ₄ ·4H ₂ O	c		672.2	S 10.4
ZrOSO ₄ ·SO ₃	c		519.4	S 32.8
ZrOSO ₄ ·H ₂ SO ₄	c		600.0	S 20.6
ZrO(NO ₃) ₂	aq.		291.7	
ZrO(NO ₃) ₂ ·2H ₂ O	c		426.2	S 2.17
ZrO(NO ₃) ₂ ·3H ₂ O	c		497.3	S - 0.5
ZrO(NO ₃) ₂ ·3½H ₂ O	c		532.9	S - 1.92
ZrO(NO ₃) ₂ ·6H ₂ O	c		707.8	S - 5.90
ZrC	c		44.	

Hafnium

Atomic number 72

Standard state Hf (c)

Atomic weight 178.6

Hf	c		0.000	
HfO ₂	c	monoclinic	271.5	

Thorium

Atomic number 90

Standard state Th (c)

Atomic weight 232.12

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Th	g		- 177.	
	c		0.000	
Th ⁺⁺⁺⁺	aq.		238.5	
ThO ₂	c		293.	
ThH ₄	c		- 42.8	<i>D</i> - 21.4
Th(OH) ₄	c	"soluble"	336.1	<i>S</i> 39.1 _{HCl(15)}
	c	"insoluble"	325.1	<i>S</i> 50.2 _{HCl(15)}
ThCl ₄	c		335.	<i>S</i> 56.7 ¹⁵
	aq.		392.	
ThCl ₄ ·2H ₂ O	c		487.2	<i>S</i> 41.1
ThCl ₄ ·4H ₂ O	c		639.2	<i>S</i> 26.23
ThCl ₄ ·7H ₂ O	c		856.0	<i>S</i> 14.7
ThCl ₄ ·8H ₂ O	c		927.6	<i>S</i> 11.45
ThOCl ₂	c		336.	<i>S</i> 28.15
ThCl ₃ OH·H ₂ O	c		398.8	<i>S</i> 47.6
ThBr ₄	c		281.5	<i>S</i> 70.2
	aq.		351.7	
ThBr ₄ ·7H ₂ O	c		807.8	<i>S</i> 22.55
ThBr ₄ ·10H ₂ O	c		1025.7	<i>S</i> 9.84
ThBr ₄ ·12H ₂ O	c		1170.0	<i>S</i> 2.3
ThOBr ₂	c		319.0	<i>S</i> 28.0
ThI ₄	aq.		291.7	
ThOI ₂	c		289.5	<i>S</i> 21.5
ThOI ₂ ·3½H ₂ O	c		425.6	<i>S</i> 10.03
ThI ₃ OH·10H ₂ O	c		1008.4	<i>S</i> 8.44
ThOSO ₄	c		517.	
Th(SO ₄) ₂	c		632.	
	aq.		667.9	
Th(SO ₄) ₂ ·4H ₂ O	c		936.4	<i>S</i> 5.0
Th(SO ₄) ₂ ·8H ₂ O	c		1222.4	<i>S</i> - 7.5
Th ₃ N ₄	c		301.4	
ThCl ₄ ·2NH ₄ Cl	c		494.5	<i>S</i> 39.8
ThCl ₄ ·2NH ₄ Cl·10H ₂ O	c		1221.1	<i>S</i> - 3.9
ThCl ₄ ·4NH ₃	c	α	458.8	<i>S</i> 61.7 _{HCl(aq.)}
ThCl ₄ ·6NH ₃	c	α	511.8	<i>S</i> 73.1 _{HCl(aq.)}
[Th(NH ₃) ₆]Cl ₄	c	β	548.9	<i>S</i> 35.3 _{HCl(aq.)}
ThCl ₄ ·7NH ₃	c	α	524.3	<i>S</i> 82.75 _{HCl(aq.)}
[Th(NH ₃) ₆]Cl ₄ ·NH ₃	c	β	581.9	<i>S</i> 34.15 _{HCl(aq.)}
[Th(NH ₃) ₆]Cl ₄ ·6NH ₃	c	β	684.4	<i>S</i> 93.7 _{HCl(aq.)}
ThCl ₄ ·12NH ₃	c	α	638.4	<i>S</i> 139.7 _{HCl(aq.)}
ThCl ₄ ·18NH ₃	c	α	747.1	<i>S</i> 214.2 _{HCl(aq.)}
[Th(NH ₃) ₆]Cl ₄ ·12NH ₃	c	β	789.4	<i>S</i> 171.9 _{HCl(aq.)}
ThC ₂	c		45.	

Boron

Atomic number 5

Standard state B (c)

Atomic weight 10.82

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
B	g	2p (² P _{1/2})	— 115.	
	c		0.000	
B*	g	2p (² P _{3/2})	— 115.04	E^* — 0.04
	g	3s (² S _{1/2})	— 228.99	E^* — 113.99
B ⁺	g	2s ² (¹ S ₀)	— 307.4	I^* — 190.97
B ⁺ *	g	2s2p (³ P ₁₀)	— 413.0	E^* — 105.57
	g	(³ P ₁)	— 413.0	E^* — 105.59
	g	(³ P ₂)	— 413.0	E^* — 105.64
B ⁺⁺	g	2s (² S _{1/2})	— 885.8	I^* — 576.89
B ⁺⁺⁺	g	1s ² (¹ S ₀)	— 1557.1	I^* — 870.92
B ⁺⁺⁺⁺	g	1s (² S _{1/2})	— 7512.	I^* — 5954.
B ⁺⁺⁺⁺⁺	g	(¹ S ₀)	— 15313.0	I^* — 7809.6
BO	g	² Σ ⁺	— 35.	D^* — 138.
BO ₂ ⁻	aq.		174.2	
BO ₃ ⁻⁻⁻	aq.		215.3	
B ₂ O ₃	gls.		279.9	S 7.3
	aq.		287.2	
B ₄ O ₇ ⁻⁻	aq.		637.6	
BH	g	¹ Σ ⁺	— 87.	D^* — 79.6
B ₂ H ₄	g			V — 3.1
HBO ₂	c		178.2	D — 13.3
H ₂ BO ₃	c		251.6	S — 5.39 ₄₀₀
	aq.		246.2	
H ₂ B ₄ O ₇	c		641.7	D — 12.3
H ₂ B ₆ O ₁₀	c		927.0	D — 13.3
BF ₃	g		256.9	S — 24.5
	liq.			V — 4.68 ⁻¹⁰¹
	aq.		281.4	
BF ₄ ⁻	aq.		358.0	
HBFB ₄	aq.		358.0	
BCl ₃	g		88.3	
	liq.		94.6	
BBr ₃	g		35.0	V — 7.75
	liq.		42.8	S 83.8 ¹¹ ₄₀₀
B ₂ H ₅ Br	liq.			V — 6.25
B ₂ S ₃	c		40.	S 58.0
NH ₄ BO ₂	1320		206.1	
	200		205.88	
NH ₄ BO ₃	aq.		230.4	
NH ₄ BO ₃ ·H ₂ O	c		307.8	S — 9.03
(NH ₄) ₂ HBO ₃	300		296.4	
(NH ₄) ₂ BO ₃	aq.		316.7	
B(CH ₃) ₃	liq.			V — 4.85

Aluminum

Atomic number 13

Standard state Al (c)

Atomic weight 26.97

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Al	g	3s ² 3p (² P _{1/2})	- 55.	
	liq.			F - 2.3 ⁶⁵⁹
	c		0.000	
Al*	g	3s ² 3p (² P _{3/2})	- 55.32	E^* - 0.32
	g	3s ² 4s (² S _{1/2})	- 127.17	E^* - 72.17
Al ⁺	g	3s ² (¹ S ₀)	- 193.9	I^* - 137.45
Al ⁺ *	g	3s3p (³ P ₀)	- 300.4	E^* - 106.45
	g	(³ P ₁)	- 300.5	E^* - 106.63
	g	(³ P ₂)	- 300.9	E^* - 106.98
Al ⁺⁺	g	(² S _{1/2})	- 627.7	I^* - 432.32
Al ⁺⁺ *	g	3p (² P _{1/2})	- 780.5	E^* - 152.82
	g	(² P _{3/2})	- 781.2	E^* - 153.70
Al ⁺⁺⁺	g	2p ⁶ (¹ S ₀)	-1282.3	I^* - 653.2
	aq.		126.3	
Al ⁺⁺⁺⁺	g	2p ⁵	-4120.	I^* -2835.
Al ₂ O ₃	g		260.	V - 116. ²⁷⁰⁰
	c		380.0	
AlH	g		- 35.0	D^* - 71.0
Al(OH) ₃	c		304.9	
AlF ₃	c		329.	S 31.
	aq.		360.2	
AlF ₆ ---	aq.		591.	
H ₃ AlF ₆	aq.		589.6	
AlF ₃ · $\frac{1}{2}$ H ₂ O	c		375.4	S 25.6 _{HF (4.75)}
AlF ₃ · $3\frac{1}{2}$ H ₂ O	c	"soluble"	601.2	S - 1.7
	c	"insoluble"	601.7	S 4.44 _{HF (4.75)}
AlCl ₃	g		133.	D - 40.
	liq.			F - 8.49 ¹⁹²
	c		166.8	S 77.9
	600		244.7	
AlCl ₃ ·6H ₂ O	c		641.7	S 13.2 ¹⁶ ₄₅₀
Al ₂ Cl ₆	g		306.1	
AlBr ₃	liq.			F - 2.7 ⁹⁸
	c		126.7	S 85.3 ⁹ ₃₀₀₀
	aq.		212.0	
AlI ₃	liq.			F - 3.8 ¹⁹¹
	c		77.2	S 89.0 ⁹ ₂₂₀₀
	aq.		166.2	
Al ₂ S ₃	c		140.5	S 75.0
Al ₂ (SO ₄) ₃	c		770.	D - 17.
	aq.		896.	
Al ₂ (SO ₄) ₃ ·6H ₂ O	c		1250.	S 56.
Al ₂ (SO ₄) ₃ ·18H ₂ O	c		2120.	S 8.2
AlCl ₃ · $\frac{1}{2}$ SO ₂	c		208.8	S 75.3
AlCl ₃ ·SO ₂	c		248.8	S 74.7
AlCl ₃ · $\frac{1}{2}$ H ₂ S	c		174.4	S 75.3 ¹⁵ ₅₀₀₀
AlCl ₃ ·H ₂ S	c		181.4	D - 9.2
AlBr ₃ ·H ₂ S	c		141.7	D - 9.72 ⁹⁰

Aluminum

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
$\text{AlI}_3 \cdot \text{H}_2\text{S}$	c		106.1	<i>D</i> — 9.1 ¹¹
$\text{AlI}_3 \cdot 4\text{H}_2\text{S}$	c		129.3	<i>D</i> — 6.3-74
AlN	c		80.	
$\text{AlF}_3 \cdot 2\text{NH}_4\text{F} \cdot 1\frac{1}{2}\text{H}_2\text{O}$	c		691.5	<i>S</i> — 8.54 ¹⁶
$\text{AlCl}_3 \cdot \text{NH}_3$	c		216.0	<i>S</i> 54.5 ¹⁵
$\text{AlCl}_3 \cdot \text{NH}_4\text{Cl}$	c		255.3	<i>S</i> 60.47 ¹⁵ ₈₀₀
$\text{AlCl}_3 \cdot 3\text{NH}_3$	c		282.7	<i>S</i> 30.3 ¹⁵
$\text{AlCl}_3 \cdot 5\text{NH}_3$	c		342.8	<i>S</i> 9.05 ¹⁵ ₂₃₀₀
$\text{AlCl}_3 \cdot 6\text{NH}_3$	c		364.9	<i>S</i> 6.35 ¹⁵ ₂₆₀₀
$\text{AlCl}_3 \cdot 7\text{NH}_3$	c		386.1	<i>D</i> — 10.2
$\text{AlCl}_3 \cdot \text{NH}_4\text{Cl} \cdot 6\text{NH}_3$	c		454.5	<i>S</i> — 2.7
$\text{AlCl}_3 \cdot 14\text{NH}_3$	c		517.5	<i>D</i> — 7.8-heptammine
$\text{AlBr}_3 \cdot \text{NH}_3$	c		177.0	<i>S</i> 66.9 ⁰ _{HBr (20)}
$\text{AlBr}_3 \cdot 3\text{NH}_3$	c		249.6	<i>S</i> 57.7 ⁰ _{HBr (20)}
$\text{AlBr}_3 \cdot 5\text{NH}_3$	c		310.6	<i>S</i> 60.2 ⁰ _{HBr (20)}
$\text{AlBr}_3 \cdot 6\text{NH}_3$	c		335.9	<i>D</i> — 16.2
$\text{AlBr}_3 \cdot 7\text{NH}_3$	c		357.5	<i>D</i> — 10.7
$\text{AlBr}_3 \cdot 9\text{NH}_3$	c		396.4	<i>D</i> — 8.4
$\text{AlBr}_3 \cdot 14\text{NH}_3$	c		516.3	<i>D</i> — 7.72
$\text{AlI}_3 \cdot \text{NH}_3$	c		119.9	<i>S</i> 78.9 ⁰ _{HI (20)}
$\text{AlI}_3 \cdot 3\text{NH}_3$	c		204.0	<i>S</i> 58.0 ⁰ _{HI (20)}
$\text{AlI}_3 \cdot 5\text{NH}_3$	c		282.0	<i>S</i> 42.0 ⁰ _{HI (20)}
$\text{AlI}_3 \cdot 6\text{NH}_3$	c		306.8	<i>S</i> 50.3 ⁰ _{HI (20)}
$\text{AlI}_3 \cdot 7\text{NH}_3$	c		329.7	<i>D</i> — 11.7
$\text{AlI}_3 \cdot 9\text{NH}_3$	c		368.5	<i>D</i> — 8.6
$\text{AlI}_3 \cdot 13\text{NH}_3$	c		443.4	<i>D</i> — 7.74
$\text{AlI}_3 \cdot 20\text{NH}_3$	c		574.6	<i>D</i> — 7.67
NH_4AlSO_4	c		531.	
$\text{NH}_4\text{AlSO}_4 \cdot 5\text{H}_2\text{O}$	c		912.	
$\text{NH}_4\text{AlSO}_4 \cdot 9\text{H}_2\text{O}$	c		1208.2	<i>D</i> — 12.0
$\text{NH}_4\text{AlSO}_4 \cdot 12\text{H}_2\text{O}$	c		1417.6	<i>S</i> — 9.2
$\text{AlCl}_3 \cdot \text{PH}_3$	c		179.0	<i>D</i> — 9.9
$\text{AlBr}_3 \cdot \text{PH}_3$	c		143.3	<i>D</i> — 14.3
$\text{AlI}_3 \cdot \text{PH}_3$	c		94.2	<i>D</i> — 14.7
Al_2C_3	c		60.	
Al_2SiO_5	c	andalusite	617.0	<i>S</i> 90.1 _{HF (4,44)}
	c	disthene	617.4	<i>S</i> 89.7 _{HF (4,44)}
	c	sillimanite	623.7	<i>S</i> 80.4 _{HF (4,44)}
$3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$	c	mullite	1804.	<i>S</i> 83.7 _{HF (4,44)}
$2\text{AlCl}_3 \cdot 3\text{PbI}_2$	c		236.0	<i>S</i> 222.0 ¹⁵
$2\text{AlCl}_3 \cdot 3\text{PbI}_2 \cdot 10\text{H}_2\text{O}$	c		1126.7	<i>S</i> 15.0 ¹⁵
$\text{AlCl}_3 \cdot \frac{1}{2}\text{ZnCl}_2$	c		237.2	<i>S</i> 94.0
AlCu	c		68.	<i>S</i> 181.bromine water
AlCu_3	c		23.	<i>S</i> 303.bromine water
Al_2Cu	c		84.	<i>S</i> 366.bromine water
$\text{AlCl}_3 \cdot \text{AgCl}$	c		199.2	<i>S</i> 75.7 ²²
Al_3Fe	c		25.0	<i>S</i> 371. _{HCl (8)}
AlCo	c		32.	<i>S</i> 106. _{HCl (8)}
Al_3Co	c		86.	<i>S</i> 565.9 _{HCl (8)}

Scandium

Atomic number 21

Standard state Sc (c)

Atomic weight 45.10

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Sc	g	3d4s ² (² D _{3/2})	— 70.	
	c		0.000	
Sc*	g	3d4s ² (² D _{5/2})	— 70.48	E^* — 0.479
	g	3d ² 4s (⁴ F _{5/2})	— 102.79	E^* — 32.79
	g	(⁴ F _{5/2})	— 102.90	E^* — 32.90
	g	(⁴ F _{7/2})	— 103.05	E^* — 33.05
	g	(⁴ F _{9/2})	— 103.24	E^* — 33.24
Sc ⁺	g	3d4s (³ D ₁)	— 225.	I^* — 154.
Sc ⁺ *	g	(³ D ₂)	— 225.2	E^* — 0.19
	g	(³ D ₂)	— 225.5	E^* — 0.51
	g	(¹ D)	— 232.2	E^* — 7.23
	g	3d ² (³ F ₂)	— 238.7	
	g	(³ F ₃)	— 238.9	E^* — 13.90
	g	(³ F ₄)	— 239.1	E^* — 14.20
Sc ⁺⁺	g	3d (² D _{3/2})	— 522.	I^* — 296.
	g	(² D _{5/2})	— 522.6	E^* — 0.56
Sc ⁺⁺⁺	g	(¹ S ₀)	— 1022.	I^* — 568.5
Sc ₂ O ₃	c		410.	
ScCl ₃	c		200.	

Yttrium

Atomic number 39

Standard state Y (c)

Atomic weight 88.92

Y	g	4d5s ² (² D _{3/2})	— 90.	
	c		0.000	
Y*	g	4d5s ² (² D _{5/2})	— 91.51	E^* — 1.510
	g	5s ² 5p (² P _{1/2})	— 119.97	E^* — 29.97
	g	(² P _{3/2})	— 122.34	E^* — 32.34
	g	4d ² (³ F)5s (⁴ F _{3/2})	— 121.14	E^* — 31.14
	g	(⁴ F _{5/2})	— 121.51	E^* — 31.51
	g	(⁴ F _{7/2})	— 122.11	E^* — 32.11
	g	(⁴ F _{9/2})	— 122.83	E^* — 32.83
Y ⁺	g	5s ² (¹ S ₀)	— 241.	I^* — 150.
Y ⁺ *	g	4d5s (³ D ₁)	— 243.4	E^* — 2.392
	g	(³ D ₂)	— 244.0	E^* — 2.975
	g	(¹ D ₂)	— 250.4	E^* — 9.38
Y ⁺⁺	g	4d (² D _{3/2})	— 526.	I^* — 284.
Y ⁺⁺ *	g	(² D _{5/2})	— 528.1	E^* — 2.06
Y ⁺⁺⁺	g	4p ⁶	— 1008.	I^* — 470.5
	aq.	(estimated)	130.	
Y ₂ O ₃	c		440.	
Y(OH) ₃	c	ppt.	336.7	
YCl ₃	c		240.	S 45.36 ¹⁸ ₂₀₀
	aq.		285.4	
Y ₂ (SO ₄) ₃	aq.		974.1	
Y ₂ (SO ₄) ₃ ·8H ₂ O	c		1510.4	S 10.68 ²⁰ ₁₂₀₀

Lutecium

Atomic number 71 Standard state Lu (c) Atomic weight 175.0

Ytterbium

Atomic number 70 Standard state Yb (c) Atomic weight 173.04

Thulium

Atomic number 69 Standard state Tm (c) Atomic weight 169.4

Erbium

Atomic number 68 Standard state Er (c) Atomic weight 165.20

Formula	State	Description	Q_f , <i>kcal. mole</i> ⁻¹	Q , <i>kcal. mole</i> ⁻¹
Er	c		0.000	
Er ⁺⁺⁺	aq.	(estimated)	150.	
Er(OH) ₃	c	ppt.	326.8	
Er(C ₂ H ₃ O ₂) ₃	aq.	erbium acetate	503.9	
Er(C ₂ H ₃ O ₂) ₃ ·4H ₂ O	c		776.0	<i>S</i> 1.36 ²⁰ ₁₅₀₀

Holmium

Atomic number 67 Standard state Ho (c) Atomic weight 163.5

Dysprosium

Atomic number 66 Standard state Dy (c) Atomic weight 162.46

Terbium

Atomic number 65 Standard state Tb (c) Atomic weight 159.2

Gadolinium

Atomic number 64 Standard state Gd (c) Atomic weight 157.3

Europium

Atomic number 63 Standard state Eu (c) Atomic weight 152.0

Samarium

Atomic number 62 Standard state Sm (c) Atomic weight 150.43

Sm	c		0.000	
Sm ⁺⁺⁺	aq.	(estimated)	160.	
Sm ₂ O ₃	c		430.	<i>S</i> 94.6 _{HCl(aq.)}
SmCl ₃	c		241.0	<i>S</i> 37.4
	aq.		278.4	
SmCl ₃ ·NH ₃	c		272.6	<i>D</i> - 20.7 ³⁷⁵
SmCl ₃ ·2NH ₃	c		300.0	<i>D</i> - 16.4 ²⁴⁰
SmCl ₃ ·3NH ₃	c		326.0	<i>D</i> - 15.1 ²⁰⁰
SmCl ₃ ·4NH ₃	c		350.7	<i>D</i> - 13.7 ¹⁵⁵
SmCl ₃ ·5NH ₃	c		373.7	<i>D</i> - 12.1 ¹⁰⁵
SmCl ₃ ·8NH ₃	c		440.2	<i>D</i> - 11.2 ⁷⁶
SmCl ₃ ·9½NH ₃	c		471.6	<i>D</i> - 10.0 ⁴⁰
SmCl ₃ ·11½NH ₃	c		491.9	<i>D</i> - 9.2 ¹⁵

Illinium

Atomic number 61

Standard state II (c)

Atomic weight (146?)

Neodymium

Atomic number 60

Standard state Nd (c)

Atomic weight 144.27

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
Nd	c		0.000	
Nd+++	aq.		164.	
Nd ₂ O ₃	c	"high temperature"	435.	
Nd ₂ O ₃	c	"low temperature"	427.	<i>S</i> 105.5 _{HCl(aq.)}
NdCl ₃	c		246.7	<i>S</i> 35.5 ₂₀₀₀
NdCl ₃	aq.		282.2	
NdCl ₃ ·6H ₂ O	c		684.8	<i>S</i> 7.6 ¹⁵ ₂₀₀₀
NdI ₃	c		155.4	<i>S</i> 48.9 ¹⁹ ₂₀₀₀
	aq.		204.3	
Nd ₂ S ₃	c		262.7	<i>S</i> 75.8 ¹⁸ _{HCl(110)}
Nd ₂ (SO ₄) ₃	c		931.5	<i>S</i> 36.5 ₆₀₀
	aq.		968.	
Nd ₂ (SO ₄) ₃ ·5H ₂ O	c		1301.6	<i>S</i> 8.3
Nd ₂ (SO ₄) ₃ ·8H ₂ O	c		1508.2	<i>S</i> 6.7
NdCl ₃ ·NH ₃	c		277.8	<i>D</i> — 20.2 ³⁶⁰
NdCl ₃ ·2NH ₃	c		305.7	<i>D</i> — 16.9 ²⁶⁸
NdCl ₃ ·4NH ₃	c		355.0	<i>D</i> — 13.7 ¹⁶⁷
NdCl ₃ ·5NH ₃	c		378.4	<i>D</i> — 12.5 ¹¹⁷
NdCl ₃ ·8NH ₃	c		444.9	<i>D</i> — 11.2 ⁷⁰
NdCl ₃ ·11NH ₃	c		506.2	<i>D</i> — 9.5 ²⁶
NdCl ₃ ·12NH ₃	c		525.6	<i>D</i> — 8.4 ⁻¹⁰

Praseodymium

Atomic number 59

Standard state Pr (c)

Atomic weight 140.92

Pr	c		0.000	
Pr+++	aq.		170.	
PrO ₂	c		231.5	<i>S</i> 42.9 _{HNO₃(s)}
Pr ₂ O ₃	c		439.4	<i>S</i> 106.2 _{HCl(aq.)}
Pr ₆ O ₁₁	c		1376.	<i>S</i> 270.6 _{HNO₃(s)}
PrCl ₃	c		254.9	<i>S</i> 33.5 ₂₀₀₀
	aq.		288.4	
PrCl ₃ ·H ₂ O	c		327.9	<i>S</i> 28.9 ¹⁷ ₂₀₀₀
PrCl ₃ ·7H ₂ O	c		761.7	<i>S</i> 5.3
Pr(NO ₃) ₃	aq.		317.9	

Cerium

Atomic number 58

Standard state Ce (c)

Atomic weight 140.13

Formula	State	Description	Q_f , <i>kcal. mole</i> ⁻¹	Q , <i>kcal. mole</i> ⁻¹
Ce	c		0.000	
Ce ⁺⁺⁺	aq.		165.	
CeO ₂	c		233.4	
Ce ₃ H ₈	c		169.	
Ce ₂ (OH) ₂ OOH	c		398.6	
CeCl ₃	c		261.5	<i>S</i> 31.5
	aq.		283.	
Ce(SO ₄) ₂	c		424.	<i>D</i> -103.5
Ce ₂ (SO ₄) ₃	aq.		977.	
Ce ₂ (SO ₄) ₃ ·4 $\frac{1}{3}$ H ₂ O	c		1260.4	<i>S</i> 16.1
CeN	c		78.2	<i>S</i> 119.2 _{HCl (20)}
CeCl ₃ ·2NH ₃	c		306.2	<i>D</i> - 11.4 ¹⁰⁰
CeCl ₃ ·4NH ₃	c		349.0	<i>D</i> - 10.4 ⁶⁷
CeCl ₃ ·8NH ₃	c		428.5	<i>D</i> - 8.9 ²⁰
CeCl ₃ ·12NH ₃	c		503.9	<i>D</i> - 7.9 ⁻¹²
CeCl ₃ ·20NH ₃	c		650.9	<i>D</i> - 7.4 ⁻³⁰
CeHg ₄	c		23.2	
CeZn ₄	c		49.	
CeAl ₄	c		22.	<i>S</i> 620. _{HCl (20)}
Ce ₂ Al	c		39.	<i>S</i> 596.5 _{HCl (20)}

Lanthanum

Atomic number 57

Standard state La (c)

Atomic weight 138.92

La	g	5d6s ² (² D _{3/2})	- 90.	
	c		0.000	
La*	g	5d6s ² (² D _{5/2})	- 93.00	<i>E</i> * - 3.00
	g	5d ² (³ F)6s (⁴ F _{3/2})	- 97.59	<i>E</i> * - 7.59
	g	(⁴ F _{5/2})	- 98.57	<i>E</i> * - 8.57
	g	(⁴ F _{7/2})	- 99.95	<i>E</i> * - 9.95
	g	(⁴ F _{9/2})	- 101.73	<i>E</i> * - 11.73
La ⁺⁺⁺	aq.		165.9	
La ₂ O ₃	c		457.0	
La ₃ H ₈	c		160.	<i>S</i> 333. _{HCl (aq.)}
LaCl ₃	c		253.1	<i>S</i> 31.3 ¹⁶ ₁₂₀₀
	aq.		284.4	
LaS ₂	c		148.3	<i>S</i> 31.8 _{HCl (aq.)}
La ₂ S ₃	c		351.4	<i>S</i> 71.8 _{HCl (9.4)}
La ₂ (SO ₄) ₃	aq.		972.	
La ₂ (SO ₄) ₃ ·8H ₂ O	c		1514.9	<i>S</i> 4.0 ₂₄₀₀
LaN	c		72.8	<i>S</i> 127.1 _{HCl (20)}
LaAl ₄	c		20.	

Actinium

Atomic number 89

Standard state Ac (c)

Atomic weight (227.?)

Beryllium

Atomic number 4

Standard state Be (c)

Atomic weight 9.02

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Be	g	2s ² (¹ S ₀)	— 75.	
	liq.			F — 2.5 ¹²⁸⁰
	c		0.000	
Be*	g	2s2p (³ P ₀)	— 137.58	E^* — 62.577
	g	(³ P ₁)	— 137.58	E^* — 62.578
	g	(³ P ₂)	— 137.59	E^* — 62.585
Be ⁺	g	2s (² S _{1/2})	— 290.51	I^* — 214.06
Be ⁺ *	g	2p (² P _{1/2})	— 380.40	E^* — 90.90
	g	(² P _{3/2})	— 380.41	E^* — 90.91
Be ⁺⁺	g	1s ² (¹ S ₀)	— 800.0	I^* — 380.41
	aq.		85.	
Be ⁺⁺⁺	g	1s (² S _{1/2})	— 4333.6	I^* — 3532.2
Be ⁺⁺⁺⁺	g		— 9333.1	I^* — 4998.1
BeO	g		— 12.6	
	c		135.0	
BeH	g		— 52.6	
BeH ⁺	g		— 661.	
BeH ⁺ *	g		— 861.	E^* — 200.
Be(OH) ₂	c	ppt.	206.8	
BeF ₂	aq.		240.8	
H ₂ BeF ₄	aq.		392.6	
BeCl ₂	g		83.0	
	liq.			F — 3.0 ⁴⁰⁵
	c		112.6	S 51.1
	aq.		163.7	
	C ₂ H ₅ OH		150.	S 37.4 _{C₂H₅OH}
BeBr ₂	g		48.	
	c		79.4	S 55.7 _{HCl(g)}
	aq.		142.	
BeI ₂	g		11.	
	c		39.4	S 62.5 _{HCl(aq.)}
	aq.		112.	
BeSO ₄	c		281.	
	aq.		299.1	
BeSO ₄ ·H ₂ O	c		354.	D — 23.4
BeSO ₄ ·2H ₂ O	c		427.9	S 8.0 ^{14,1000}
BeSO ₄ ·4H ₂ O	c		571.5	S 1.10 ₄₀₀
BeBr ₂ ·2H ₂ S	c		107.7	
BeI ₂ ·2H ₂ S	c		64.0	
Be(NO ₃) ₂	aq.		183.4	
BeCl ₂ ·2NH ₃	c		234.5	D — 18.2
BeCl ₂ ·4NH ₃	c		292.8	S 28.3 _{HCl(g)}
BeCl ₂ ·6NH ₃	c		330.7	D — 8.04
BeCl ₂ ·12NH ₃	c		442.0	D — 7.8

Beryllium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
BeBr ₂ ·4NH ₃	c		165.6	<i>S</i> 33.7 _{HCl(g)}
BeBr ₂ ·6NH ₃	c		304.7	<i>D</i> — 8.8
BeBr ₂ ·10NH ₃	c		379.9	<i>D</i> — 7.85
BeI ₂ ·4NH ₃	c		231.2	<i>S</i> 34.8 _{HCl(aq.)}
BeI ₂ ·6NH ₃	c		272.5	<i>D</i> — 8.9
BeI ₂ ·13NH ₃	c		404.0	<i>D</i> — 7.9

Magnesium

Atomic number 12

Standard state Mg (c)

Atomic weight 24.32

Mg	g	3s ² (¹ S ₀)	— 36.3	
	liq.			<i>F</i> — 1.70 ⁰⁰⁰
	c		0.000	
Mg*	g	3s3p (³ P ₁₀)	— 98.51	<i>E</i> [*] — 62.21
	g	(³ P ₁₁)	— 98.56	<i>E</i> [*] — 62.26
	g	(³ P ₁₂)	— 98.68	<i>E</i> [*] — 62.38
Mg ⁺	g	3s (² S _{1/2})	— 213.31	<i>I</i> [*] — 175.56
Mg ⁺ *	g	3p (² P _{1/2})	— 314.86	<i>E</i> [*] — 101.55
	g	(² P _{3/2})	— 315.10	<i>E</i> [*] — 101.79
Mg ⁺⁺	g	2p ⁶ (¹ S ₀)	— 559.98	<i>I</i> [*] — 345.22
	∞		110.23	
Mg ⁺⁺⁺	g	2p ⁵ (² P _{3/2})	— 2414.	<i>I</i> [*] — 1853.
	g	(² P _{1/2})	— 2420.	<i>E</i> [*] — 6.05
Mg ⁺⁺⁺⁺	g	2p ⁴ (³ P ₂)	— 4931.	<i>I</i> [*] — 2515.6
MgO	c		146.1	
MgH	g	² Σ	— 55.7	
MgH*	g	² Π	— 109.4	
MgH ⁺	g	¹ Σ ⁺	— 222.5	
Mg(OH) ₂	c	ppt.	218.7	
	c	brucite	223.9	<i>D</i> — 19.4
MgF	g		— 95.	
MgF ₂	c	ppt.	263.8	
MgCl ₂	c		153.3	<i>S</i> 35.9 ₈₀₀
	∞		189.60	
	6400		189.43	
	3200		189.37	
	1600		189.30	
	800		189.22	
	400		189.13	
	200		189.02	
	100		188.81	

Magnesium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
MgCl ₂	50		188.53	
	20		187.61	
	10		185.29	
MgCl ₂ ·2H ₂ O	c		305.5	<i>S</i> 20.4 ₄₀₀
MgCl ₂ ·4H ₂ O	c		452.6	<i>S</i> 10.0 ₄₀₀
MgCl ₂ ·6H ₂ O	c		596.4	<i>S</i> 2.9 ₄₀₀
	liq.			<i>F</i> — 9.6 ¹²⁰
MgCl ₂ ·MgO	c		421.1	<i>S</i> 14.5 _{HCl(aq.)}
MgCl ₂ ·MgO·6H ₂ O	c		810.2	<i>S</i> 36. _{HCl(aq.)}
MgCl ₂ ·MgO·16H ₂ O	c		1507.9	<i>S</i> 22.0 _{HCl(aq.)}
MgO·HCl	c		194.1	
MgBr ₂	c		123.9	<i>S</i> 43.3
	∞		167.57	
	6400		167.41	
	3200		167.35	
	1600		167.29	
	800		167.22	
	400		167.16	
MgBr ₂ ·H ₂ O	c		200.0	<i>D</i> — 18.3
MgBr ₂ ·6H ₂ O	c		558.	<i>D</i> — 11.7
MgI ₂	c		86.8	<i>S</i> 49.8
	∞		136.97	
	6400		136.82	
	3200		136.77	
	1600		136.71	
	800		136.65	
	400		136.61	
MgS	c		82.2	<i>S</i> 38.0 ¹³ _{HCl(aq.)}
	aq.		108.	
MgSO ₃	c		240.0	<i>S</i> 16.88 ¹² _{HCl(220)}
MgSO ₃ ·3H ₂ O	c		460.8	<i>S</i> 1.17 _{HCl(220)}
MgSO ₃ ·6H ₂ O	c		672.7	<i>S</i> — 5.63 _{HCl(220)}
MgSO ₄	c		304.95	<i>S</i> 20.30 ₄₀₀
	∞		326.03	
	6400		325.52	
	3200		325.42	
	1600		325.30	
	800		325.25	
	400		325.25	
	200		325.18	
	100		325.11	
	50		325.07	
	20		324.79	
MgSO ₄ ·H ₂ O	c		380.4	<i>S</i> 13.3 ₄₀₀
MgSO ₄ ·2H ₂ O	c		451.03	<i>S</i> 11.05 ₄₀₀

Magnesium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
MgSO ₄ ·4H ₂ O	c		594.6	<i>S</i> 4.24 ₄₀₀
MgSO ₄ ·6H ₂ O	c		735.7	<i>S</i> — 0.10 ₄₀₀
MgSO ₄ ·7H ₂ O	c		807.8	<i>S</i> — 3.85 ₄₀₀
MgS ₂ O ₈	aq.		390.1	
MgS ₂ O ₈ ·6H ₂ O	c		803.3	<i>S</i> — 2.97 ₄₀₀
Mg(HS) ₂	aq.		117.4	
Mg ₃ N ₂	c		116.	
Mg(NO ₃) ₂	∞		208.610	
	550000		208.587	
	62000		208.558	
	11300		208.485	
	5500		208.442	
	2460		208.385	
	1375		208.343	
	555		208.278	
	400		208.27	
	200		208.22	
	100		208.21	
	50		208.25	
	20		208.26	
	15		208.11	
	12		207.85	
Mg(NO ₃) ₂ ·6H ₂ O	c		622.5	<i>S</i> — 4.22 ₄₀₀
	liq.			<i>F</i> — 9.7 ⁹⁰
Mg(NH ₄) ₂ ⁺⁺	aq.		148.5	
MgCl ₂ ·NH ₃	c		185.0	<i>D</i> — 20.8
MgCl ₂ ·2NH ₃	c		215.6	<i>D</i> — 19.7
	aq.		227.5	
MgCl ₂ ·6NH ₃	c		312.7	<i>D</i> — 13.3
MgBr ₂ ·NH ₃	c		156.7	<i>D</i> — 21.7
MgBr ₂ ·2NH ₃	c		187.7	<i>D</i> — 20.1
MgBr ₂ ·6NH ₃	c		292.4	<i>D</i> — 15.2
MgI ₂ ·2NH ₃	c		154.3	<i>D</i> — 22.7
MgI ₂ ·6NH ₃	c		267.0	<i>D</i> — 17.2
3MgSO ₃ ·(NH ₄) ₂ SO ₃ ·6H ₂ O	c		1381.9	<i>S</i> 8.9 _{HCl(aq.)}
3MgSO ₃ ·(NH ₄) ₂ SO ₃ ·18H ₂ O	c		2233.5	<i>S</i> — 22.3 _{HCl(aq.)}
MgSO ₄ ·(NH ₄) ₂ SO ₄ ·4H ₂ O	c		936.2	
MgSO ₄ ·(NH ₄) ₂ SO ₄ ·6H ₂ O	c		1024.4	<i>S</i> — 9.7
Mg ₃ (PO ₄) ₂	c	ppt.	915.8	
	aq.		926.	
MgHPO ₄	aq.		415.	
MgNH ₄ PO ₄ ·6H ₂ O	c		901.4	
Mg ₃ (AsO ₄) ₂	c	ppt.	731.3	
	aq.		749.	
MgHAsO ₄	aq.		323.	

Magnesium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>	
Mg(H ₂ AsO ₄) ₂	aq.		541.		
MgNH ₄ AsO ₄ ·6H ₂ O	c		763.9		
MgCO ₃	c		268.		
MgCO ₃ ·H ₂ O	c		339.8		
MgCO ₃ ·3H ₂ O	c		480.8		
Mg(C ₂ H ₃ O ₂) ₂	∞	magnesium acetate	346.12		
Mg(C ₂ H ₃ O ₂) ₂	c	magnesium glycollate	415.0	<i>S</i>	4.4
	aq.		419.4		
Mg(C ₂ H ₃ O ₂) ₂ ·2H ₂ O	c		557.7	<i>S</i> —	1.5
MgCl ₂ ·6CH ₃ OH	c		517.	<i>D</i> —	12.
MgCN ₂	c	magnesium cyanamide	61.	<i>C</i>	179.2
			40.4		
Mg(CN) ₂	aq.				
Mg(NO ₃) ₂ ·6CH ₃ OH	c			<i>D</i> —	13.77
MgSiO ₃	c		347.5		
Mg ₂ Sn	c		59.		
2MgI ₂ ·PbI ₂	c		206.9	<i>S</i>	110.5 ¹⁵
MgZn ₂	c		13.1		
MgCd	c	I		<i>T</i>	0.28 ²⁴² —II
	c	II	9.2	<i>S</i>	123.7 _{HCl(s)}
MgHg ₄	c		17.3		
MgBr ₂ ·HgBr ₂	4400		207.4		
MgBr ₂ ·2HgBr ₂	4200		245.0		
2MgBr ₂ ·HgBr ₂	4800		376.5		
Mg(CN) ₂ ·Hg(CN) ₂	600		— 11.9		
Mg(CN) ₂ ·2Hg(CN) ₂	900		— 75.6		
MgCl ₂ ·2Hg(CN) ₂	1000		59.3		
MgCl ₂ ·2Hg(CN) ₂ ·6H ₂ O	c		479.9	<i>S</i> —	10.3 ¹⁸
MgBr ₂ ·2Hg(CN) ₂	1000		38.5		
MgBr ₂ ·2Hg(CN) ₂ ·8H ₂ O	c		601.5	<i>S</i> —	16.0 ¹⁴
MgI ₂ ·2Hg(CN) ₂	1000		12.7		
MgI ₂ ·2Hg(CN) ₂ ·8H ₂ O	c		579.6	<i>S</i> —	20.0 ¹⁵
MgMoO ₄	c		329.9		
MgWO ₄	c		345.2		
Mg ₄ Al ₃	c		49.0	<i>S</i>	779 _{HCl(s)}
MgCe	c		13.0	<i>S</i>	260.5 ²⁵ _{HCl(s)}
Mg ₃ Ce	c		17.0	<i>S</i>	477.3 ²⁵ _{HCl(s)}
Mg ₇ B ₁₀ O ₃ Cl ₂	c	borocite		<i>T</i> —	1.3 ²⁶⁵

Calcium

Atomic number 20

Standard state Ca (c, II)

Atomic weight 40.08

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
Ca	g	4s ² (¹ S ₀)	— 47.8	
	liq.			F — 9.6 ⁸⁰⁰
	c	I		T 0.10 ⁴⁰⁰ → II
Ca*	c	II	0.000	
	g	4s4p (³ P ₁₀)	— 90.95	E^z — 43.15
	g	(³ P ₁₁)	— 90.10	E^z — 43.30
Ca ⁺	g	(³ P ₁₁)	— 91.40	E^z — 43.60
	g	4s (² S _{1/2})	— 189.61	I^z — 140.36
Ca ⁺ *	g	3d (² D _{3/2})	— 228.47	E^z — 38.86
	g	(² D _{5/2})	— 228.63	E^z — 39.02
	g	4p (² P _{1/2})	— 261.33	E^z — 71.72
Ca ⁺⁺	g	(² P _{3/2})	— 261.96	E^z — 72.35
	g	3p ⁶ (¹ S ₀)	— 463.63	I^z — 272.57
	∞		129.74	
Ca ⁺⁺⁺	g	3p ⁶ (² P _{3/2})	— 1642.2	I^z — 1176.1
CaO	g		29.	
	liq.			F — 28. ²⁵⁷⁰
	c		151.7	
	c	prepared at 1000°		
			151.8	
CaO ₂	c		156.4	S 18.9 _{HCl(100)}
CaO ₂ ·8H ₂ O	c		719.0	
CaH	g		— 55.3	D^z — 43.5
CaH ₂	c		46.	S 82.7 _{HCl(aq.)}
Ca(OH) ₂	c		236.0	
	∞		239.06	
	800		238.7	
Ca(OH) ₂ ·H ₂ O ₂	c		291.2	
CaF	g		— 3.	
CaF ₂	c		290.2	
	∞		286.14	
			286.14	
CaCl	c	(?)	96.9	S 72.2 _{HCl(aq.)}
CaCl ₂	c	fused	190.6	S 18.0 ₂₀₀
	∞		209.117	
	6400		208.954	
	3200		208.898	
	1600		208.835	
	800		208.771	
	400		208.688	
	200		208.6	
	100		208.501	
	50		208.363	
	20		208.78	
	10		206.15	

Calcium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
$CaCl_2$	6		204.2	
$CaCl_2 \cdot H_2O$	c		265.2	<i>S</i> 11.7 ₄₀₀
$CaCl_2 \cdot 2H_2O$	c		333.4	<i>S</i> 10.0 ₄₀₀
$CaCl_2 \cdot 4H_2O$	c		480.2	<i>S</i> 1.85 ₄₀₀
$CaCl_2 \cdot 6H_2O$	c		623.45	<i>S</i> — 4.56 ₄₀₀
	liq.		614.4	
$CaCl_2 \cdot 2CaO$	c		505.4	<i>S</i> 99.5 ¹³ _{HCl(aq.)}
$CaCl_2 \cdot 3CaO$	c		656.	<i>S</i> 147.3 ¹³ _{HCl(aq.)}
$CaCl_2 \cdot 3CaO \cdot 3H_2O$	c		910.5	<i>S</i> 97.7 ¹³ _{HCl(aq.)}
$CaCl_2 \cdot 3CaO \cdot 16H_2O$	c		1833.8	<i>S</i> 63.4 ¹³ _{HCl(aq.)}
$CaOCl_2$	c		177.9	<i>S</i> 9.83
	aq.		187.8	
$CaOCl_2 \cdot H_2O$	c		248.6	<i>S</i> 7.53
$Ca(ClO)_2$	aq.		180.2	
$CaBr_2$	c		102.22	<i>S</i> 24.5 ₄₀₀
	∞		187.08	
	6400		186.95	
	3200		186.88	
	1600		186.83	
	800		186.77	
	400		186.72	
$CaBr_2 \cdot 6H_2O$	c		598.2	<i>S</i> — 1.09 ₄₀₀
$CaBr_2 \cdot 3CaO \cdot 3H_2O$	c		888.5	<i>S</i> 97.7 ¹⁶ _{HBr(aq.)}
$CaBr_2 \cdot 3CaO \cdot 16H_2O$	c		1811.6	<i>S</i> 93.5 ²⁰ _{HBr(aq.)}
CaI_2	c		128.48	<i>S</i> 27.70 ₄₀₀
	∞		156.48	
	6400		156.34	
	3200		156.30	
	1600		156.26	
	800		156.21	
	400		156.18	
$CaI_2 \cdot 8H_2O$	c		701.6	<i>S</i> 1.74 ²⁰
$CaI_2 \cdot 3CaO \cdot 16H_2O$	c		1781.2	<i>S</i> 63.4 _{HI(aq.)}
CaS	c		113.4	<i>S</i> 26.3 ¹¹ _{HCl(aq.)}
	aq.		119.8	
$CaSO_3 \cdot 2H_2O$	c		418.7	
$CaSO_4$	c	"insoluble"	340.7	
	c	"soluble"	340.4	
	∞		345.54	
	6400		344.97	
	3200		344.86	
	1600		344.75	
	800		(344.71)	
$CaSO_4 \cdot \frac{1}{2}H_2O$	c		376.11	
$CaSO_4 \cdot 2H_2O$	c		482.46	<i>S</i> — 0.84 ₃₀₀

Calcium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
CaS ₂ O ₃	800		275.2	
	350		275.05	
	230		275.01	
	116		274.87	
	34		274.60	
CaSe	c		81.8	<i>S</i> 34.8 _{HCl(200)}
CaN ₆	c		75.8	
Ca ₃ N ₂	c		109.5	<i>S</i> 342.7 _{HCl(aq.)}
CaN ₂ O ₂ ·4H ₂ O	c		405.4	
Ca(NO ₃) ₂	c		224.04	<i>S</i> 3.94 ₄₀₀
	∞		228.12	
	6400		227.98	
	3200		227.96	
	1600		227.94	
	800		227.94	
	400		227.98	
	200		228.24	
	100		228.29	
	4		228.3	
200 C ₂ H ₅ OH			231.5	<i>S</i> 7.41 ²⁵ _{C₂H₅OH}
Ca(NO ₃) ₂ ·H ₂ O	c		295.8	
Ca(NO ₃) ₂ ·2H ₂ O	c		368.07	<i>S</i> — 3.35 ₄₀₀
Ca(NO ₃) ₂ ·3H ₂ O	c		437.41	<i>S</i> — 4.32 ₄₀₀
Ca(NO ₃) ₂ ·4H ₂ O	c		509.59	<i>S</i> — 8.13 ₄₀₀
	liq.		501.8	
Ca(NH ₂) ₂	c		91.5	<i>S</i> 101.7 ¹⁴ _{HCl(aq.)}
Ca(NO ₃) ₂ ·Ca(OH) ₂	c		461.2	<i>S</i> 33.2 _{HNO₃(aq.)}
Ca(NO ₃) ₂ ·Ca(OH) ₂ ·2½H ₂ O	c		552.2	<i>S</i> 24.8 _{HNO₃(aq.)}
CaCl ₂ ·NH ₃	c		218.5	<i>D</i> — 17.
CaCl ₂ ·2NH ₃	c		244.5	<i>D</i> — 15.0
CaCl ₂ ·4NH ₃	c		287.0	<i>D</i> — 10.1
CaCl ₂ ·8NH ₃	c		370.4	<i>D</i> — 9.8
CaBr ₂ ·NH ₃	c		191.9	<i>D</i> — 18.6
CaBr ₂ ·2NH ₃	c		219.9	<i>D</i> — 17.0
CaBr ₂ ·6NH ₃	c		310.5	<i>D</i> — 11.7
CaBr ₂ ·8NH ₃	c		351.9	<i>D</i> — 9.8
CaI ₂ ·NH ₃	c		159.2	<i>D</i> — 19.7
CaI ₂ ·2NH ₃	c		189.2	<i>D</i> — 19.0
CaI ₂ ·6NH ₃	c		289.0	<i>D</i> — 14.0
CaI ₂ ·8NH ₃	c		327.7	<i>D</i> — 8.4
CaSO ₄ ·(NH ₄) ₂ SO ₄ ·H ₂ O	c		694.5	<i>S</i> — 2.16
2CaSO ₄ ·(NH ₄) ₂ SO ₄	c		964.7	<i>S</i> 4.38
5CaSO ₄ ·(NH ₄) ₂ SO ₄ ·H ₂ O	c		2070.1	<i>S</i> 2.32
Ca ₃ (PO ₄) ₂	c		983.	
	aq.		984.	

Calcium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Ca ₃ (PO ₄) ₂	colloid	in water	977.	
CaHPO ₄	aq.		434.	
CaHPO ₄ ·2H ₂ O	c		571.7	
Ca(H ₂ PO ₄) ₂	aq.		744.	
Ca(H ₂ PO ₄) ₂ ·H ₂ O	c		813.	
Ca(H ₂ PO ₄) ₂ ·H ₂ O·NH ₃	c		835.6	<i>D</i> — 11.6
Ca(H ₂ PO ₄) ₂ ·H ₂ O·2NH ₃	c		855.6	<i>D</i> — 9.1
Ca(H ₂ PO ₄) ₂ ·H ₂ O·4NH ₃	c		892.8	<i>D</i> — 7.6
Ca ₃ (AsO ₄) ₂	c	ppt.	794.	
	aq.		808.	
CaHASO ₄	aq.	ppt.	343.	
Ca(H ₂ AsO ₄) ₂	aq.	ppt.	560.	
CaC ₂	c		14.5	<i>S</i> 60.8 _{HCl(100)}
CaCO ₃	c	calcite, I	289.5	<i>S</i> 3.24 ²⁵ _{HCl(50)}
	c	aragonite, II	289.54	<i>T</i> — 0.04 ²⁵ _{→I}
CaC ₂ O ₄	c	ppt., calcium oxalate	333.1	
Ca(CHO ₂) ₂	c	calcium formate	328.3	<i>S</i> 0.66 ¹⁶ ₃₀₀
	400		329.0	
Ca(HCO ₃) ₂	aq.	calcium bicarbonate	460.2	
Ca(C ₂ H ₃ O ₂) ₂	c	calcium acetate	358.0	<i>S</i> 7.0 ¹⁴ ₄₄₀
	∞		365.64	
Ca(C ₂ H ₃ O ₂) ₂ ·H ₂ O	c		427.5	<i>S</i> 5.86 ¹⁷ ₄₄₀
Ca(C ₂ H ₃ O ₃) ₂	c	calcium glycollate	443.2	<i>S</i> — 1.62
	aq.		441.6	
Ca(C ₂ H ₃ O ₃) ₂ ·3H ₂ O	c		653.8	<i>S</i> — 7.06
Ca(C ₂ H ₃ O ₃) ₂ ·5H ₂ O	c		791.0	<i>S</i> — 7.6
Ca(C ₂ H ₃ O ₂) ₂	c	calcium alcoholate	229.0	<i>S</i> 40.27 ¹⁵ _{HCl(110)}
Ca(C ₂ H ₃ O ₂) ₂ ·2C ₂ H ₅ OH	c		372.1	<i>S</i> 36.8 _{HCl(110)}
3CaO·4C ₂ H ₅ OH	c		780.5	<i>S</i> 92.9 _{HCl(aq.)}
CaCl ₂ ·3C ₂ H ₅ OH	c		405.8	<i>D</i> — 14.6
CaCl ₂ ·4C ₂ H ₅ OH	c		474.9	<i>D</i> — 12.
CaCl ₂ ·(CH ₃) ₂ CO	c			<i>D</i> — 11.4
CaBr ₂ ·3C ₂ H ₅ OH	c		380.2	<i>D</i> — 15.5
CaBr ₂ ·4C ₂ H ₅ OH	c		451.9	<i>D</i> — 14.6
CaCN ₂	c		85.	<i>S</i> 161.2
Ca(CN) ₂	aq.		60.2	
Ca(NO ₃) ₂ ·2CH ₃ OH	c		344.1	<i>D</i> — 11.4
3CaO·Ca(CN) ₂ ·15H ₂ O	c		1608.0	<i>S</i> 94.0 ¹⁸ _{HCl(aq.)}
CaSi	c		87.	

Calcium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
CaSi ₃	c		220.	
CaSiO ₃	c	II, wollastonite	377.9	$T - 1.26_{+I}$
	c	I, pseudowollastonite		
			376.6	
CaSiO ₄	gls.		537.	
CaSn ₃	c		52.	
CaI ₂ ·2PbI ₂	c		223.4	$S \quad 16.61^{15}_{500}$
CaI ₂ ·2PbI ₂ ·7H ₂ O	c		713.3	$S \quad 5.3$
CaZn ₄	c		29.5	$S \quad 219.5_{HCl(20)}$
CaZn ₁₀	c		48.	$S \quad 381._{HCl(20)}$
Ca ₂ Zn ₃	c		40.	$S \quad 307.8_{HCl(20)}$
Ca ₄ Zn	c		32.	$S \quad 512._{HCl(20)}$
CaCd ₃	c		30.	$S \quad 159.6_{HCl(s)}$
CaBr ₂ ·HgBr ₂	4400		226.9	
CaBr ₂ ·2HgBr ₂	8400		264.5	
Ca(CN) ₂ ·Hg(CN) ₂	900		8.4	
Ca(CN) ₂ ·2Hg(CN) ₂	900		— 54.85	
CaCl ₂ ·2Hg(CN) ₂	1000		79.5	
CaCl ₂ ·2Hg(CN) ₂ ·6H ₂ O	c		504.3	$S \quad 14.6^{15}$
CaBr ₂ ·2Hg(CN) ₂	1000		58.4	
CaBr ₂ ·2Hg(CN) ₂ ·7H ₂ O	c		556.8	$S \quad 19.8^{15}$
CaI ₂ ·2Hg(CN) ₂	1000		32.2	
CaI ₂ ·2Hg(CN) ₂ ·6H ₂ O	c		464.8	$S \quad 22.4$
Ca(CN) ₂ ·AgCN	1000		68.8	
Ca(CN) ₂ ·2AgCN	500		7.5	
CaO·Fe ₂ O ₃	c		399.	
Ca ₂ Fe(CN) ₆	aq.		138.1	$N \quad 56.4$
Ca ₂ Fe(CN) ₆ ·12H ₂ O	c		963.2	$S - 4.6^{10}$
CaH ₂ Fe(CN) ₆	aq.		8.1	$N \quad 28.4$
CaWO ₄	c		387.	
CaO·B ₂ O ₃	c		462.7	$S \quad 22.5_{HCl(aq.)}$
CaO·2B ₂ O ₃	c		751.5	$S \quad 20.9_{HCl(aq.)}$
2CaO·B ₂ O ₃	c		632.2	$S \quad 51.0_{HCl(aq.)}$
3CaO·B ₂ O ₃	c		797.8	$S \quad 83.35_{HCl(aq.)}$
CaAl ₃	c		51.	$S \quad 454._{HCl(s)}$
CaO·Al ₂ O ₃	gls.		620.	
2CaO·Al ₂ O ₃	gls.		857.	
3CaO·Al ₂ O ₃	gls.		1098.	
3CaCl ₂ ·4AlCl ₃	c		1457.8	$S \quad 146.8$
3CaO·Al ₂ O ₃ ·2SiO ₂	c		1292.	
CaO·Al ₂ O ₃ ·6SiO ₂	c		3287.	$S \quad 286._{HF(4.44)}$
Ca ₂ Mg ₄	c		43.	$S \quad 800._{HCl(s)}$
CaCl ₂ ·2MgCl ₂ ·2H ₂ O	c		701.0	$S \quad 22.3$
CaCO ₃ ·MgCO ₃	c	dolomite	559.7	

Strontium

Atomic number 38

Standard state Sr (c)

Atomic weight 87.63

Formula	State	Description	Q_f , $kcal, mole^{-1}$	$Q, kcal. mole^{-1}$
Sr	g	5s ² (¹ S ₀)	— 47.	
	liq.			F — 1.4 ⁷⁶⁰
	c		0.000	
Sr*	g	5s5p (³ P ₁₀)	— 87.76	E^* — 40.759
	g	(³ P ₁₁)	— 88.29	E^* — 41.291
	g	(³ P ₂)	— 89.41	E^* — 42.414
	g	5s5d (³ D ₁)	— 98.70	E^* — 51.697
	g	(³ D ₂)	— 98.87	E^* — 51.866
	g	(³ D ₃)	— 99.15	E^* — 52.152
Sr ⁺	g	5s (² S _{1/2})	— 179.19	I^* — 130.74
Sr ⁺ *	g	4d (² D ₂)	— 212.63	E^* — 41.44
	g	(² D ₃)	— 213.43	E^* — 42.238
Sr ⁺⁺	g	4p ⁶ (² S _{1/2})	— 425.59	I^* — 252.95
	∞		130.04	
SrO	g		— 3.0	V_S — 140.0 ¹²⁰
	c		140.8	S 30.0 ¹⁵ ₁₁₀₀
SrO ₂	c		153.3	S 22.23 ¹⁸ _{HCl(900)}
SrO ₂ ·9H ₂ O	c		789.2	S 1.74 ¹⁸ _{HCl(200)}
Sr ₂ O	c		153.6	S 174.9 ¹⁵ _{HCl(aq.)}
SrH ₂	c		42.1	S 88.0 ⁷ _{HCl(200)}
Sr(OH) ₂	c		228.7	S 10.5 ¹¹⁰⁰
	∞		239.36	
	800		239.2	
Sr(OH) ₂ ·H ₂ O	c		302.1	S 5.26 ¹⁸ ₁₁₀₀
Sr(OH) ₂ ·8H ₂ O	c		800.5	S — 14.27 ¹⁸ ₁₁₀₀
SrF	g		— 27.	D — 77.
SrF ₂	c		289.0	
SrCl	c	(?)	106.5	S 63.0 ¹⁸ _{HCl(100)}
SrCl ₂	c		197.87	S 11.15 ⁴⁰⁰
	∞		209.41	
	6400		209.25	
	3200		209.20	
	1600		209.13	
	800		209.07	
	400		209.02	
	200		209.0	
	100		208.987	
	50		208.978	
SrCl ₂ ·H ₂ O	c		271.4	S 6.0 ¹⁷ ₄₀₀
SrCl ₂ ·2H ₂ O	c		343.2	S 2.51 ⁴⁰⁰
SrCl ₂ ·6H ₂ O	c		626.7	S — 7.51 ⁴⁰⁰
Sr(ClO) ₂	aq.		179.9	N 17.8
SrCl ₂ ·SrO·H ₂ O	c		436.7	S 39.3 ²² _{HCl(100)}
SrCl ₂ ·SrO·9H ₂ O	c		1006.2	S 16.72 ²² _{HCl(100)}

Strontium

Formula	State	Description	Q_f , $kcal, mole^{-1}$	$Q, kcal. mole^{-1}$
SrBr ₂	c		171.0	S 16.1 ₄₀₀
	∞		187.38	
	6400		187.23	
	3200		187.19	
	1600		187.14	
	800		187.09	
	400		187.06	
SrBr ₂ ·H ₂ O	c		246.5	S 8.9 ₄₀₀
SrBr ₂ ·2H ₂ O	c		317.6	S 6.2 ₄₀₀
SrBr ₂ ·4H ₂ O	c		460.5	S 0.0 ₄₀₀
SrBr ₂ ·6H ₂ O	c		603.7	S — 6.45 ₄₀₀
SrBr ₂ ·SrO·3H ₂ O	c		552.7	S 38.5 _{HBr(aq.)}
SrBr ₂ ·SrO·9H ₂ O	c		984.8	S 16.45 ²⁰ _{HBr(aq.)}
SrI ₂	c		136.1	S 20.6
	∞		156.78	
	6400		156.64	
	3200		156.60	
	1600		156.57	
	800		156.54	
	400		156.52	
SrI ₂ ·H ₂ O	c		212.5	S 12.4
SrI ₂ ·2H ₂ O	c		283.1	S 10.17 ¹⁰
SrI ₂ ·6H ₂ O	c		571.5	S — 4.73
SrS	c		113.1	S 27.0 _{HCl(aq.)}
	aq.		120.3	
SrSO ₄	c		345.3	
	∞		345.8	
	6400		345.2	
	3200		345.1	
	1600		345.0	
	800		344.9	
	400		344.8	
SrS ₂ O ₆	aq.		410.2	
SrS ₂ O ₆ ·4H ₂ O	c		693.0	S — 9.25 ₄₀₀
Sr(HS) ₂	aq.		137.9	
SrI ₂ ·2SO ₂	c		300.2	D — 11.1
SrI ₂ ·4SO ₂	c		463.5	D — 10.7
SrSe	c		83.4	S 33.6
	aq.		104.6	
SrN ₆	c		— 49.0	
Sr ₃ N ₂	c		92.2	S 361.6 _{HCl(200)}
SrN ₂ O ₂	aq.		126.4	
SrN ₂ O ₂ ·5H ₂ O	c		474.0	
Sr(NO ₃) ₂	c		233.2	S — 4.7 ₄₀₀
	∞		228.420	

Strontium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Sr(NO ₃) ₂	550000		228.403	
	21000		228.348	
	5550		228.313	
	2000		228.304	
	1000		228.340	
	400		228.52	
	200		228.78	
	100		228.91	
	50		229.90	
	20		231.16	
			514.3	<i>S</i> - 12.3 ₄₀₀
Sr(NO ₃) ₂ ·4H ₂ O	c		82.8	<i>S</i> 110.8 ⁷ _{HCl(200)}
Sr(NH ₂) ₂	c		123.3	<i>D</i> - 9.6
Sr·6NH ₃	c		220.3	<i>D</i> - 11.5
SrCl ₂ ·NH ₃	c		241.7	<i>D</i> - 10.5
SrCl ₂ ·2NH ₃	c		370.0	<i>D</i> - 10.4
SrCl ₂ ·8NH ₃	c		198.3	<i>D</i> - 16.8
SrBr ₂ ·NH ₃	c		222.0	<i>D</i> - 12.8
SrBr ₂ ·2NH ₃	c		375.5	<i>D</i> - 10.9
SrBr ₂ ·8NH ₃	c		165.4	<i>D</i> - 18.3
SrI ₂ ·NH ₃	c		191.9	<i>D</i> - 15.5
SrI ₂ ·2NH ₃	c		286.1	<i>D</i> - 12.8
SrI ₂ ·6NH ₃	c		330.0	<i>D</i> - 11.0
SrI ₂ ·8NH ₃	c		627.6	<i>S</i> - 3.20
SrSO ₄ ·(NH ₄) ₂ SO ₄	c		980.	
Sr ₃ (PO ₄) ₂	c	ppt.	985.	
	aq.		434.	
SrHPO ₄	aq.		745.	
Sr(H ₂ PO ₄) ₂	aq.		797.	
Sr ₃ (AsO ₄) ₂	c	ppt.	809.	
	aq.		343.	
SrHAsO ₄	aq.		560.	
Sr(H ₂ AsO ₄) ₂	aq.		290.4	
SrCO ₃	c		503.4	
SrC ₂ O ₄ ·2½H ₂ O	c	strontium oxalate hydrate	328.0	<i>S</i> 0.62 ¹⁵ ₈₀₀
Sr(CHO ₂) ₂	c	strontium formate	329.6	
	aq.		470.7	<i>S</i> - 5.46 ¹¹ ₈₀₀
	c			
Sr(CHO ₂) ₂ ·2H ₂ O	c		459.7	
Sr(HCO ₃) ₂	aq.	strontium bicarbonate	359.7	<i>S</i> 5.56 ¹² ₈₀₀
Sr(C ₂ H ₃ O ₂) ₂	c	strontium acetate	365.93	
	∞		365.3	
	400		394.2	<i>S</i> 5.26 ¹² ₈₀₀
Sr(C ₂ H ₃ O ₂) ₂ ·½H ₂ O	c			

Strontium

Formula	State	Description	Q_f , <i>kcal. mole</i> ⁻¹	Q , <i>kcal. mole</i> ⁻¹
Sr(C ₂ H ₃ O ₃) ₂	c	glycollate	444.3	<i>S</i> — 1.2
	aq.		443.1	
SrBr ₂ ·1½CH ₃ OH	c		257.8	<i>D</i> — 9.14
Sr(CN) ₂	aq.		60.2	
Sr(CN) ₂ ·4H ₂ O	c		338.6	<i>S</i> — 4.15 ⁸ ₂₀₀
SrSiO ₃	gls.		364.	
SrI ₂ ·2PbI ₂	c		222.9	<i>S</i> 17.55
SrI ₂ ·2PbI ₂ ·7H ₂ O	c		714.3	<i>S</i> 4.70 ¹⁵
SrHg _∞	liq.		59.5	
SrBr ₂ ·HgBr ₂	4400		227.3	
SrBr ₂ ·2HgBr ₂	8400		265.0	
2SrBr ₂ ·HgBr ₂	4800		416.8	
Sr(CN) ₂ ·Hg(CN) ₂	600		8.0	
Sr(CN) ₂ ·2Hg(CN) ₂	900		— 55.2	
SrCl ₂ ·2Hg(CN) ₂	1000		79.8	
SrCl ₂ ·2Hg(CN) ₂ ·6H ₂ O	c		505.8	<i>S</i> — 15.8 ¹⁵
SrBr ₂ ·2Hg(CN) ₂	1000		58.9	
SrBr ₂ ·2Hg(CN) ₂ ·6H ₂ O	c		487.7	<i>S</i> — 18.6 ¹⁵
SrI ₂ ·2Hg(CN) ₂	1000		32.6	
SrI ₂ ·2Hg(CN) ₂ ·7H ₂ O	c		533.0	<i>S</i> — 21.8
Sr(CN) ₂ ·AgCN	600		34.1	
Sr(CN) ₂ ·2AgCN	500		6.6	
Sr ₃ (FeCO(CN) ₅) ₂	c		266.5	<i>S</i> 39.9 ¹³ ₃₀₀
	aq.		306.4	
Sr ₃ (FeCO(CN) ₅) ₂ ·4H ₂ O	c		547.5	<i>S</i> 32.4 ¹³ ₆₇₀₀
Sr(CN) ₂ ·Ni(CN) ₂	aq.		95.7	
SrWO ₄	c		393.	
3SrCl ₂ ·4AlCl ₃	c		1277.0	<i>S</i> 328.8 ²¹ ₁₈₀₀

Barium

Atomic number 56

Standard state Ba (c)

Atomic weight 137.36

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Ba	g	6s ² (¹ S ₀)	— 49.	
	liq.			F — 1.40 ⁶⁶⁰
	c		0.000	
Ba*	g	6s5d (³ D ₁)	— 74.72	E° — 25.717
	g	(³ D ₂)	— 75.23	E° — 26.234
	g	(³ D ₃)	— 76.32	E° — 27.319
	g	(¹ D ₂)	— 81.44	E° — 32.437
	g	6s6p (³ P ₁₀)	— 83.92	E° — 34.919
	g	(³ P ₁₁)	— 84.74	E° — 35.739
	g	(³ P ₁₂)	— 87.47	E° — 38.473
Ba ⁺	g	6s (² S _{1/2})	— 160.10	I° — 119.645
Ba ⁺ *	g	(² D _{3/2})	— 173.97	E° — 13.874
	g	(² D _{5/2})	— 176.25	E° — 16.155
	g	6p (² P _{1/2})	— 217.78	E° — 57.68
	g	(² P _{3/2})	— 223.58	E° — 62.49
Ba ⁺⁺	g	5p ⁶ (¹ S ₀)	— 391.16	I° — 229.61
	∞		128.36	
BaO	g		40.	V — 90.0 ¹²⁰⁰
	c		133.	
BaO ₂	c		152.4	S 22.0 ¹³ _{HCl(820)}
BaO ₂ ·H ₂ O	c		223.4	S 19.1 _{HCl(aq.)}
BaO ₂ ·10H ₂ O	c		855.1	S 2.72
Ba ₂ O	c		149.	S 176.4 ¹⁵ _{HCl(aq.)}
BaH ₂	c		40.8	S 87.6 ⁷ _{HCl(aq.)}
Ba(OH) ₂	c		225.9	S 11.60 ⁶⁹⁰
	∞		237.68	
	400		237.43	
Ba(OH) ₂ ·H ₂ O	c		298.6	S 7.06 ¹⁵ ₆₆₀
Ba(OH) ₂ ·8H ₂ O	c		798.9	S — 14.50 ¹⁵ ₆₈₀
BaO ₂ ·H ₂ O ₂	c		208.1	S 11.8 ¹² _{HCl(aq.)}
BaF ₂	c		287.9	
	∞		284.76	
	1600		284.4	
BaCl ₂	c		205.28	S 2.07 ₄₀₀
	∞		207.73	
	6400		207.57	
	3200		207.52	
	1600		207.46	
	800		207.40	
	400		207.350	
	200		207.3	
	100		207.272	
	50		207.308	
BaCl ₂ ·H ₂ O	c		278.27	S — 1.55 ₄₀₀

Barium

Formula	State	Description	Q_f , $kcal, mole^{-1}$	Q , $kcal. mole^{-1}$
BaCl ₂ ·2H ₂ O	c		349.0	<i>S</i> — 4.92 ₄₀₀
Ba(ClO) ₂	aq.		180.	
Ba(ClO ₂) ₂	c		157.8	
Ba(ClO ₃) ₂	c		176.6	<i>S</i> — 6.7 ¹⁰ ₈₀₀
	∞		169.86	
	1600		169.9	
Ba(ClO ₃) ₂ ·H ₂ O	c		248.8	<i>S</i> — 11.24 ₈₀₀
Ba(ClO ₄) ₂	c		210.2	<i>S</i> — 1.8 ¹⁰ ₈₀₀
	∞		207.36	
	800		208.2	
Ba(ClO ₄) ₂ ·3H ₂ O	c		423.0	<i>S</i> — 9.4
BaCl ₂ ·BaO·3H ₂ O	c		578.5	
BaCl ₂ ·BaO·5H ₂ O	c		727.6	
BaCl ₂ ·BaO·8H ₂ O	c		931.6	
BaBr ₂	c		180.41	<i>S</i> 4.98 ₄₀₀
	∞		185.70	
	6400		185.56	
	3200		185.51	
	1600		185.46	
	800		185.42	
	400		185.39	
BaBr ₂ ·H ₂ O	c		254.9	<i>D</i> — 16.70
BaBr ₂ ·2H ₂ O	c		326.31	<i>S</i> — 4.18 ₄₀₀
Ba(BrO) ₂	aq.		176.	
Ba(BrO ₃) ₂	∞		150.76	
	800		151.6	
Ba(BrO ₃) ₂ ·H ₂ O	c		235.0	<i>S</i> — 15.06
BaBr ₂ ·BaO·2H ₂ O	c		485.2	<i>S</i> 33.8 _{HBr(aq.)}
BaBr ₂ ·BaO·5H ₂ O	c		704.7	<i>S</i> 18.5 ²⁰ _{HBr(aq.)}
BaI ₂	c		144.6	<i>S</i> 10.29 ¹⁸
	∞		155.10	
	6400		154.96	
	3200		154.93	
	1600		154.90	
	800		154.87	
	400		154.86	
BaI ₂ ·H ₂ O	c		220.8	<i>D</i> — 18.8
BaI ₂ ·2H ₂ O	c		291.7	<i>D</i> — 13.5
BaI ₂ ·2½H ₂ O	c		326.6	<i>D</i> — 12.9
BaI ₂ ·7H ₂ O	c		640.30	<i>S</i> — 6.85 ₄₀₀
Ba(IO ₃) ₂	c		246.5	<i>S</i> — 4.6 _{K₂SO₄(aq.)}
	∞		237.36	
Ba(IO ₃) ₂ ·H ₂ O	c		317.0	
BaI ₂ ·BaO·2H ₂ O	c		455.0	<i>S</i> 33.3 ²⁰ _{HI(aq.)}
BaI ₂ ·BaO·9H ₂ O	c		955.1	<i>S</i> 11.8 ²⁰ _{HI(aq.)}

Barium

Formula	State	Description	Q_f , <i>kcal, mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
BaS	c	ppt.	111.2	<i>S</i> 27.2 ¹⁰ _{HCl(aq.)}
	∞		118.36	
	800		118.6	
BaSO ₃	c		282.5	
BaSO ₄	c		349.4	
	∞		344.16	
BaS ₂ O ₆	aq.		408.7	
BaS ₂ O ₆ ·2H ₂ O	c		552.4	<i>S</i> — 6.93 ₄₀₀
BaS ₂ O ₈	aq.		451.7	
BaS ₂ O ₈ ·4H ₂ O	c		746.9	<i>S</i> — 11.8
Ba(HS) ₂	aq.		136.2	<i>N</i> 15.75
Ba(HSO ₃) ₂	aq.		426.0	
BaSO ₄ ·H ₂ SO ₄	c		548.0	<i>S</i> 14.25 ₂₂₆₀
BaSO ₄ ·2H ₂ SO ₄ ·H ₂ O	c		800.2	<i>S</i> 24.25 ₂₂₆₀
BaS ₄ O ₆	aq.		400.7	
BaS ₄ O ₆ ·2H ₂ O	c		544.4	<i>S</i> — 7.0 ¹⁷ ₈₀₀
BaI ₂ ·2SO ₂	c		309.3	<i>D</i> — 11.34
BaI ₂ ·4SO ₂	c		471.0	<i>D</i> — 9.91
BaSe	c		81.3	<i>S</i> 33.9 _{HCl(aq.)}
BaSeO ₄	c		277.8	
Ba(N ₂) ₂	c		19.5	<i>S</i> — 7.8
	aq.		11.7	
Ba ₃ N ₂	c		90.7	<i>S</i> 358.0 ⁸ _{HCl(aq.)}
Ba(NO ₂) ₂	c		184.6	<i>S</i> — 5.68 ¹² ₈₀₀
	aq.		178.9	
Ba(NO ₃) ₂ ·2H ₂ O	c		255.9	<i>S</i> — 8.6 ¹² ₈₀₀
Ba(NO ₃) ₂	c		236.9	<i>S</i> — 9.47 ₄₀₀
	∞		226.740	
	550000		226.728	
	21200		226.705	
	5500		226.733	
	1900		226.839	
	1380		226.875	
	800		227.049	
	400		227.27	
	200		227.90	
BaNH	c		53.6	<i>S</i> 106.5 ⁸ _{HCl(200)}
Ba(NH ₂) ₂	c		78.8	<i>S</i> 113.1 ⁸ _{HCl(200)}
Ba(NH ₃) ₆	c		74.7	<i>D</i> — 8.8
BaCl ₂ ·8NH ₃	c		364.5	<i>D</i> — 8.92
BaBr ₂ ·NH ₃	c		203.4	<i>D</i> — 12.0
BaBr ₂ ·2NH ₃	c		226.1	<i>D</i> — 11.8
BaBr ₂ ·4NH ₃	c		269.7	<i>D</i> — 10.8
BaBr ₂ ·8NH ₃	c		355.2	<i>D</i> — 10.4
BaI ₂ ·2NH ₃	c		193.3	<i>D</i> — 13.4

Barium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
BaI ₂ ·4NH ₃	c		237.9	D — 11.3
BaI ₂ ·6NH ₃	c		282.0	D — 11.1
BaI ₂ ·8NH ₃	c		325.4	D — 10.7
BaI ₂ ·9NH ₃	c		346.3	D — 10.0
BaI ₂ ·10NH ₃	c		365.0	D — 7.7
Ba ₃ (PO ₄) ₂	c	ppt.	992.	
	colloid	in water	975.	
	∞		980.	
Ba(HPO ₃) ₂	aq.		414.0	
Ba(HPO ₃) ₂ ·H ₂ O	c		482.1	S 0.29 ₄₀₀
BaH ₂ F ₂ O ₄	aq.			N 35.4
BaHPO ₄	aq.		432.	
Ba(H ₂ PO ₄) ₂	aq.		743.	
Ba ₃ (AsO ₄) ₂	c	ppt.	817.7	
	aq.		804.	
BaHAsO ₃	aq.		285.4	
BaHAsO ₄	aq.		343.0	
Ba(H ₂ AsO ₃) ₂	aq.		466.	
Ba(H ₂ AsO ₄) ₂	aq.		558.	
BaCO ₃	c		290.9	
BaC ₂ O ₄ ·H ₂ O	c	ppt., barium oxalate hydrate	397.4	
BaO·BaCO ₃	c		424.	D — 63.2
Ba(HCO ₂) ₂	c	barium formate	330.4	S — 2.44 ₈₀₀
	aq.		328.0	
Ba(HCO ₂) ₂	aq.	barium bicar- bonate	460.	
Ba(C ₂ H ₃ O ₂) ₂	c	barium acetate	358.5	S 5.24 ₁₀₀₀
	∞		364.25	
	800		363.7	
Ba(C ₂ H ₃ O ₂) ₂ ·3H ₂ O	c		569.4	S — 0.82
Ba(C ₂ H ₃ O ₂) ₂	c	barium glycollate	446.1	S — 5.08
	aq.		441.0	N 27.8
Ba(C ₂ H ₅ O) ₂	c	barium alcohol- ate	220.6	S 19.76 ¹⁰
3BaO·4CH ₃ OH	c		714.5	S 112.04 _{HCl(aq.)}
3BaO·4C ₂ H ₅ OH	c		737.5	S 49.07
Ba(C ₂ H ₅ SO ₄) ₂	aq.	barium ethyl sulfate	543.8	
			685.5	S — 4.97 ₈₀₀
Ba(C ₂ H ₅ SO ₄) ₂ ·2H ₂ O	c		57.4	S 1.8 ⁹
Ba(CN) ₂	c		58.9	N 6.3 ⁷
	aq.		129.7	S — 2.1 ⁸
Ba(CN) ₂ ·H ₂ O	c		200.5	S — 4.7 ⁷
Ba(CN) ₂ ·2H ₂ O	c		213.	S — 14.9
Ba(CNO) ₂	c	barium cyanate		

Barium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Ba(CNO) ₂	aq.	pseudo salt of nitromethane	198.	
Ba(CH ₂ NO ₂) ₂	aq.		172.6	
BaSiO ₃	gls.		363.	
BaSiF ₆	c		678.2	
	aq.		672.4	
BaI ₂ ·2PbI ₂	c		230.4	<i>S</i> 8.30 ¹⁵
BaI ₂ ·2PbI ₂ ·7H ₂ O	c		725.6	<i>S</i> — 8.29 ¹⁵
BaBr ₂ ·HgBr ₂	4400		225.7	
BaBr ₂ ·2HgBr ₂	8400		263.2	
2BaBr ₂ ·HgBr ₂	4800		413.4	
Ba(CN) ₂ ·Hg(CN) ₂	600		6.7	
Ba(CN) ₂ ·2Hg(CN) ₂	900		— 56.5	
BaCl ₂ ·2Hg(CN) ₂	1000		78.2	
BaCl ₂ ·2Hg(CN) ₂ ·5H ₂ O	c		437.2	<i>S</i> — 17.1 ¹⁵
BaBr ₂ ·2Hg(CN) ₂	1000		57.2	
BaBr ₂ ·2Hg(CN) ₂ ·6H ₂ O	c		488.4	<i>S</i> — 21.0 ¹⁵
BaI ₂ ·2Hg(CN) ₂	900		30.7	
BaI ₂ ·2Hg(CN) ₂ ·4H ₂ O	c		326.2	<i>S</i> — 22.0 ¹⁵
Ba(CN) ₂ ·AgCN	1200		32.9	
Ba(CN) ₂ ·2AgCN	500		5.2	
BaPtCl ₆	c		284.9	<i>S</i> 9.06 ¹⁹ ₅₀₀₀
	aq.		294.0	
BaPtCl ₆ ·6H ₂ O	c		705.3	<i>S</i> — 1.06 ¹⁶ ₄₀₀₀
Ba ₂ Fe(CN) ₆	aq.		134.9	<i>N</i> 55.7 ¹²
Ba ₂ Fe(CN) ₆ ·6H ₂ O	c		556.6	<i>S</i> — 11.4 ¹⁴
BaH ₂ Fe(CN) ₆	aq.		7.6	<i>N</i> 29.2
Ba ₂ (FeCO(CN) ₅) ₂	c		283.3	<i>S</i> 16.9 ¹⁵ ₁₀₀₀₀
	aq.		300.2	<i>N</i> 84.6
Ba ₂ (FeCO(CN) ₅) ₂ ·11H ₂ O	c		1059.2	<i>S</i> — 6.9 ¹³ ₂₀₀₀
BaHFeCO(CN) ₅	aq.		85.7	<i>N</i> 28.2
Ba(H ₂ FeCO(CN) ₅) ₂	aq.		42.3	<i>N</i> 28.2
Ba(CN) ₂ ·Ni(CN) ₂	aq.		48.0	
BaCrO ₄	c		342.2	
BaMoO ₄	c		370.	
BaWO ₄	c		402.	
BaCl ₂ ·2AlCl ₃	c		543.2	<i>S</i> 153.5
3BaCl ₂ ·4AlCl ₃	c		1291.3	<i>S</i> 309.4

Radium

Atomic number 88

Standard state Ra (c)

Atomic weight 225.97

Lithium

Atomic number 3

Standard state Li (c)

Atomic weight 6.940

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Li	g	2s (² S _{1/2})	— 39.0	
	liq.			F — 0.76 ¹⁸⁶
	c		0.000	
Li*	g	2s (² P _{1/2})	— 81.40	E^* — 42.399
	g	2s (² P _{3/2})	— 81.40	E^* — 42.400
Li ⁺	g	1s ² (¹ S ₀)	— 163.25	I^* — 123.796
	∞		66.628	
Li ⁺⁺	g	1s (² S _{1/2})	—1901.6	I^* —1736.86
Li ⁺⁺⁺	g		—4714.1	I^* —2811.1
Li ₂	g		— 50.8	
Li ₂ O	c		142.3	S 31.5 ₂₀₀
Li ₂ O· $\frac{3}{2}$ H ₂ O	c		220.9	S 4.23 ₂₀₀
Li ₂ O ₂	c		151.9	S 7.1 ₁₁₀
	aq.		159.	
LiH	g		— 33.0	D^* — 57.0
	c		21.59	S 31.14 ₂₀₀
LiH*	g		— 107.5	E^* — 74.8
LiOH	c		116.55	S 4.55 ₂₀₀
	∞		121.288	
	6400		121.248	
	3200		121.233	
	1600		121.211	
	800		121.182	
	400		121.147	
	200		121.1	
	100		121.045	
	50		120.965	
	25		120.845	
LiOH· $\frac{1}{2}$ H ₂ O	c		125.44	S 4.21 ₂₀₀
LiOH·H ₂ O	c		188.70	S 0.77 ₂₀₀
Li ₂ O ₂ ·H ₂ O ₂ ·3H ₂ O	c		414.	S — 4.5
LiF	g		82.	V — 52. ¹⁸⁰⁰
	liq.			F — 6.0 ⁸⁷⁰
	c		145.57	S — 0.89 ₄₀₀
	∞		144.828	
	6400		144.788	
	3200		144.772	
	1600		144.750	
	800		144.719	
	400		144.678	
	200		144.624	
	100		144.552	
LiHF ₂	400		219.93	
LiCl	g		51.	V — 37.2 ¹²⁰⁰

Lithium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
LiCl	liq.			$F - 5.0^{614}$
	c		97.65	$S - 8.49_{200}$
	∞		106.315	
	6400		106.277	
	3200		106.262	
	1600		106.242	
	800		106.215	
	400		106.183	
	200		106.140	
	100		106.084	
	50		106.003	
	25		105.865	
	20		105.795	
	15		105.67	
	12		105.54	
	10		105.39	
	8		105.16	
	6		104.68	
	5		104.30	
	4		103.63	
	3		102.54	
	48 CH ₃ OH	in methanol	108.55	$S - 10.9_{48} CH_3OH$
	24 CH ₃ OH		108.15	
	7.9 CH ₃ OH		107.05	
	4.7 CH ₃ OH		105.55	
	70 C ₂ H ₅ OH	in ethanol	108.89	$S - 11.29_{70} C_2H_5OH$
	35 C ₂ H ₅ OH			$S - 11.5^{12}_{35} C_2H_5OH$
	16.9 C ₂ H ₅ OH			$S - 11.2^{12}_{16.9} C_2H_5OH$
	5.4 C ₂ H ₅ OH			$S - 9.1^{12}_{5.4} C_2H_5OH$
LiCl·H ₂ O	c		170.23	$S - 4.28_{200}$
LiCl·2H ₂ O	c		241.98	$S - 0.90_{200}$
LiCl·3H ₂ O	c		313.4	$D - 13.6$
LiClO	aq.		92.5	
LiClO ₂	∞		87.38	
LiClO ₄	∞		106.13	
LiBr	g		39.0	$V - 36.5^{1200}$
	liq.			$F - 4.0^{549}$
	c		83.76	$S - 11.39_{200}$
	∞		95.298	
	6400		95.264	
	3200		95.254	
	1600		95.240	
	800		95.221	
	400		95.195	
	200		95.154	

Lithium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
LiBr	100		95.103	
	50		95.033	
	25		94.903	
	20		94.84	
	15		94.73	
	12		94.62	
	10		94.50	
	8		94.31	
	6		93.92	
	5		93.54	
	4		92.83	
	3		91.47	
LiBr·H ₂ O	c		158.37	<i>S</i> 5.27 ₂₀₀
LiBr·2H ₂ O	c		229.99	<i>S</i> 2.02 ₂₀₀
LiBr·3H ₂ O	c		302.0	<i>D</i> — 14.2
LiBrO	aq.		87.9	
LiBrO ₃	∞		77.83	
LiI	g		23.	<i>V</i> — 34.3 ¹⁰⁰⁰
	c		65.08	<i>S</i> 14.83 ₂₀₀
	∞		79.998	
	6400		79.968	
	3200		79.959	
	1600		79.948	
	800		79.936	
	400		79.923	
	200		79.907	
	100		79.878	
LiI·½H ₂ O	c		104.1	<i>D</i> — 10.1
LiI·H ₂ O	c		141.44	<i>S</i> 6.83 ₂₀₀
LiI·2H ₂ O	c		213.31	<i>S</i> 3.33 ₂₀₀
LiI·3H ₂ O	c		285.28	<i>S</i> — 0.27 ₂₀₀
LiIO ₃	∞		121.13	
Li ₂ SO ₄	c	I		<i>T</i> 6.8 ⁸⁶⁶ →11
	c	II	342.35	<i>S</i> 6.10 ₂₀₀
	∞		349.056	
	6400		348.872	
	3200		348.807	
	1600		348.736	
	800		348.656	
	400		348.586	
	200		348.446	
Li ₂ SO ₄ ·H ₂ O	c		413.66	<i>S</i> 3.30 ₄₀₀
LiHSO ₄	aq.		279.6	
LiI·SO ₂	c		145.8	<i>D</i> — 9.7
LiI·2SO ₂	c		226.2	<i>D</i> — 9.4

Lithium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Li ₂ Se	c		84.9	<i>S</i> 10.4 ₁₀₀
	aq.		95.3	
Li ₂ Se·9H ₂ O	c		722.3	<i>S</i> — 12.2 ₃₀₀₀
LiHSe	aq.		40.2	
Li ₃ N	c		46.4	<i>S</i> 131.1
LiNO ₃	liq.			<i>F</i> — 6.1 ²⁵⁰
	c		115.352	<i>S</i> 0.333 ₂₀₀
	∞		115.818	
	6400		115.782	
	3200		115.769	
	1600		115.753	
	800		115.733	
	400		115.710	
	200		115.685	
	100		115.661	
	50		115.638	
	25		115.613	
	10		115.58	
	3		115.3	
	385 C ₂ H ₅ OH	in ethanol	119.8	<i>S</i> 4.45 ₃₈₅ C ₂ H ₅ OH
LiNO ₃ ·3H ₂ O	c		328.8	
LiNH ₂	c		42.6	
Li(NH ₂) ₄	liq.		78.6	
Li ₂ NH	c		52.7	
LiCl·NH ₃	c		120.1	<i>S</i> 5.46 ₂₈₀
LiCl·2NH ₃	c		142.4	<i>S</i> 2.67 ₄₄₀
LiCl·3NH ₃	c		164.0	<i>S</i> 0.45 ₆₅₀
LiCl·4NH ₃	c		183.5	<i>S</i> 0.40 ₈₆₀
LiCl·5NH ₃	c		202.4	<i>D</i> — 8.0
LiBr·NH ₃	c		107.6	<i>S</i> 7.00 ₂₈₀
LiBr·2NH ₃	c		130.8	<i>S</i> 3.26 ₄₄₀
LiBr·3NH ₃	c		153.2	<i>S</i> 0.29 ₆₅₀
LiBr·4NH ₃	c		174.4	<i>S</i> — 1.50 ₈₆₀
LiBr·5NH ₃	c		193.4	<i>D</i> — 8.1
LiBr·6½NH ₃	c		220.2	<i>D</i> — 6.9
LiI·NH ₃	c		92.0	<i>D</i> — 16.0
LiI·2NH ₃	c		116.7	<i>D</i> — 13.8
LiI·3NH ₃	c		139.8	<i>D</i> — 12.2
LiI·4NH ₃	c		162.3	<i>D</i> — 11.6
LiI·5NH ₃	c		181.3	<i>D</i> — 8.1
LiI·5½NH ₃	c		190.4	<i>D</i> — 7.2
LiI·7NH ₃	c		217.5	<i>D</i> — 7.1
Li ₂ C ₂	c		13.9	<i>S</i> 37.2
Li ₂ CO ₃	c		290.1	<i>S</i> 3.15 ₂₂₀
	∞		293.76	

Lithium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	$Q, kcal. mole^{-1}$	
Li_2CO_3	2000		293.50		
$LiCHO_2$	aq.	formate	166.4		
$LiHCO_3$	2000	bicarbonate	231.43		
$LiCH_3O$	60 CH_3OH	in methanol	112.6		
LiC_2H_5O	60 C_2H_5OH	in ethanol	118.7		
$LiC_2H_5O_2$	∞	lithium acetate	184.57 ₄		
$Li_2C_2O_4$	aq.		328.9		
$LiCN$	aq.		31.73	N	2.8 ₂₂₁
$LiCNO$	aq.		101.5		
$LiCl \cdot CH_3NH_2$	c		117.6	S	6.56 ₃₃₀
$LiCl \cdot 2CH_3NH_2$	c		136.6	D -	11.7
$LiCl \cdot 3CH_3NH_2$	c		154.5	D -	10.6
$LiCl \cdot 4CH_3NH_2$	c		171.3	D -	9.5
$LiBr \cdot CH_3NH_2$	c		105.6	D -	14.5
$LiBr \cdot 2CH_3NH_2$	c		126.1	D -	13.2
$LiBr \cdot 3CH_3NH_2$	c		146.3	D -	12.9
$LiBr \cdot 4CH_3NH_2$	c		163.7	D -	10.1
$LiBr \cdot 5CH_3NH_2$	c		179.9	D -	8.9
$LiI \cdot CH_3NH_2$	c		88.7	D -	16.3
$LiI \cdot 2CH_3NH_2$	c		109.1	D -	13.1
$LiI \cdot 3CH_3NH_2$	c		127.9	D -	11.5
$LiI \cdot 3\frac{1}{2}CH_3NH_2$	c		136.1	D -	9.1
$LiCl \cdot (CH_3)_2NH$	c		114.6	D -	8.7
$LiCl \cdot 2(CH_3)_2NH$	c		130.6	D -	7.8
$LiCl \cdot 3(CH_3)_2NH$	c		146.4	D -	7.6
$LiBr \cdot \frac{1}{2}(CH_3)_2NH$	c		92.9	D -	10.2
$LiBr \cdot (CH_3)_2NH$	c		101.9	D -	9.9
$LiBr \cdot 2(CH_3)_2NH$	c		117.9	D -	7.8
$LiBr \cdot 3(CH_3)_2NH$	c		133.7	D -	7.6
$LiBr \cdot 4(CH_3)_2NH$	c		148.7	D -	6.8
$LiBr \cdot 5(CH_3)_2NH$	c		163.1	D -	6.2
$LiI \cdot \frac{1}{2}(CH_3)_2NH$	c		76.0	D -	13.5
$LiI \cdot (CH_3)_2NH$	c		85.9	D -	11.5
$LiI \cdot 1\frac{1}{2}(CH_3)_2NH$	c		95.0	D -	10.0
$LiI \cdot 2(CH_3)_2NH$	c		103.5	D -	8.9
$LiI \cdot 3(CH_3)_2NH$	c		118.3	D -	6.6
$LiI \cdot 5(CH_3)_2NH$	c		147.1	D -	6.2
$LiCl \cdot C_2H_5NH_2$	c		124.5	S	7.5 ₃₃₀
$LiCl \cdot 2C_2H_5NH_2$	c		148.6	S	9.5 ₃₃₀
$LiCl \cdot 3C_2H_5NH_2$	c		172.2	S	11.8 ₅₅₀
Li_2SiO_3	gls.		374.		
Li_2SiF_6	aq.		677.3	S	2.0 ₈₀₀
	aq.		679.3		
$2Li \cdot PbI_2$	c		140.83	S	60.90 ₁₆₀₀

Lithium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
2LiI·PbI ₂ ·4H ₂ O	c		489.13	<i>S</i> — 13.92 ₁₇₈₀
LiHg	c		20.8	
LiHg ₂	c		25.0	
LiHg ₃	c		26.8	
LiHg ₉	liq.		19.6	
LiBr·HgBr ₂	4500		134.8	
2LiBr·HgBr ₂	4600		231.2	
4LiBr·HgBr ₂	4900		423.3	
8LiBr·HgBr ₂	5900		805.4	
LiCN·Hg(CN) ₂	550	—	26.1	
2LiCN·Hg(CN) ₂	660		11.0	
LiCl·Hg(CN) ₂	550		41.5	
2LiCl·Hg(CN) ₂	660		147.7	
LiBr·Hg(CN) ₂	550		30.9	
LiBr·Hg(CN) ₂ ·3½H ₂ O	c		279.3	<i>S</i> — 9.1
2LiBr·Hg(CN) ₂	660		126.4	
LiI·Hg(CN) ₂	550		17.9	
LiI·Hg(CN) ₂ ·3½H ₂ O	c		267.5	<i>S</i> — 10.3
2LiI·Hg(CN) ₂	660		98.8	
LiCl·ThCl ₄ ·8H ₂ O	c		1019.6	<i>S</i> 25.5
2LiCl·ThCl ₄	c		535.0	<i>S</i> 69.3

Sodium

Atomic Number 11

Standard state Na (c)

Atomic weight 22.997

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Na	g	2p ² 3s (² S _{1/2})	- 25.9	
	liq.			<i>F</i> - 0.630 ⁹⁸
	c		0.000	
Na*	g	2p ² 3p (² P _{1/2})	- 74.17	<i>E</i> [*] - 48.271
	g	(² P _{3/2})	- 74.22	<i>E</i> [*] - 48.320
Na ⁺	g	2p ⁶ (¹ S ₀)	145.35	<i>I</i> [*] - 118.00
	∞		57.479	
Na ⁺⁺	g	2p ⁵ (² P _{3/2})	-1231.3	<i>I</i> [*] -1084.5
Na ⁺⁺ *	g	(² P _{1/2})	-1235.2	<i>E</i> [*] - 3.90
Na ⁺⁺⁺	g	2P ⁴	-2865.8	<i>I</i> [*] -1633.02
Na ₂	g	¹ Σ ⁺ _g	- 33.4	
Na ₂ [*]	g	¹ Σ ⁺ _u	- 76.1	<i>E</i> [*] - 42.72
	g	¹ Π _u	- 91.2	<i>E</i> [*] - 57.79
Na ₂ O	c		99.45	<i>S</i> 56.3 ₃₀₀
Na ₂ O ₂	c		119.2	
Na ₂ O	c		101.6	
NaH	c		14.	
	g	Σ	- 25.3	<i>D</i> [*] - 51.6
NaH*	g	Σ	- 91.6	<i>E</i> [*] - 66.3
NaOH	c	I		<i>T</i> 0.99 ^{100, 11}
	c	II	101.96	<i>S</i> 10.10 ₃₀₀
	∞	Na ⁺ (∞) + OH ⁻ (∞)		
	6400		112.139	
	3200		112.101	
	1600		112.089	
	800		112.076	
	400		112.063	
	200		112.053	
	100		112.061	
	50		112.1	
	25		112.184	
	20		112.312	
	18		112.351	
	15		112.361	
	12		112.371	
	10		112.348	
	8		112.282	
	6		112.14	
	5		112.55	
	4		113.02	
	3		113.86	
			115.34	
NaOH·½H ₂ O	c		138.15	<i>S</i> 8.1 ₃₀₀
NaOH·½H ₂ O	c		150.64	<i>S</i> 7.0 ₃₀₀

Sodium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	$Q, kcal. mole^{-1}$	
$NaOH \cdot \frac{3}{4}H_2O$	c		156.94	<i>S</i>	6.4 ₂₀₀
$NaOH \cdot H_2O$	c		175.34	<i>S</i>	5.09 ₂₀₀
$NaHO_2$	aq.		94.5		
NaF	g		64.	<i>V</i> —	72. ¹³⁰⁰
	liq.			<i>F</i> —	7.8 ⁹⁹⁰
	c		135.95	<i>S</i> —	0.40 ₂₀₀
	∞	$Na^+(\infty) +$ $F^-(\infty)$			
			135.679		
	6400		135.643		
	3200		135.629		
	1600		135.614		
	800		135.592		
	400		135.571		
	200		135.551		
	100		135.536		
$NaHF_2$	c		216.75	<i>S</i> —	6.0 ₄₀₀
	400		210.75		
$NaCl$	g		41.2	<i>V</i> —	43.5 ¹²⁰⁰
	liq.			<i>F</i> —	7.22 ⁸⁰⁰
	c		98.330	<i>S</i> —	1.211 ₂₀₀
	∞	$Na^+(\infty) +$ $Cl^-(\infty)$			
			97.166		
	6400		97.131		
	3200		97.121		
	1600		97.111		
	800		97.105		
	400		97.105		
	200		97.119	<i>N</i>	13.996 ₂₀₁
	100		97.171		
	50		97.286		
	25		97.496		
	20		97.581		
	15		97.701		
	12		97.792		
	10		97.850		
$NaClO$	800		83.4		
$NaClO_3$	c		83.60		
	∞	$Na^+(\infty) +$ $ClO_3^-(\infty)$			
			78.23		
	6400		78.210		
	3200		78.207		
	1600		78.208		
	800		78.220		
	400		78.248		
	200		78.335		

Sodium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
NaClO ₄	c		101.13	<i>S</i> — 3.33 ₄₀₀
	∞	Na ⁺ (∞) + ClO ₄ ⁻ (∞)	96.98	
	1600		97.28	
	800		97.58	
	400		98.05	
NaBr	g		32.9	<i>V</i> — 38.8 ¹²⁵⁰
	c		86.73	<i>S</i> — 0.60 ₂₀₀
	∞	Na ⁺ (∞) + Br ⁻ (∞)	86.149	
	6400		86.117	
	3200		86.109	
	1600		86.103	
	800		86.099	
	400		86.104	
	200		86.129	<i>N</i> 13.923 ₂₀₁
	100		86.204	
	50		86.346	
	25		86.585	
	20		86.687	
	15		86.836	
	12		86.952	
	10		87.045	
	8		87.139	
	6		87.162	
NaBr·2H ₂ O	c		227.46	<i>S</i> — 4.59 ₂₀₀
NaBrO	aq.		78.8	
NaBrO ₃	∞	Na ⁺ (∞) + BrO ₃ ⁻ (∞)	68.68	
	6400		68.661	
	3200		68.662	
	1600		68.667	
	800		68.683	
	400		68.720	
	200		68.82	
NaI	g		18.9	<i>V</i> — 38.6 ¹¹⁰⁰
	c		69.28	<i>S</i> 1.55 ₂₀₀
	∞	Na ⁺ (∞) + I ⁻ (∞)	70.849	
	6400		70.819	
	3200		70.811	
	1600		70.805	
	800		70.803	
	400		70.811	
	200		70.842	<i>N</i> 13.855 ₂₀₁

Sodium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
NaI	100		70.920	
	50		71.080	
	25		71.361	
	20		71.484	
	15		71.662	
	10		71.924	
	8		72.047	
	6		72.127	
	5		72.083	
	520 C_2H_5OH		73.67	S — 4.39 ₅₂₀ C_2H_5OH
NaI·2H ₂ O	c		211.48	S — 3.90 ₂₀₀
NaIO ₃	∞	$Na^+(\infty) + IO_3^-(\infty)$		
			111.98	
	6400		111.972	
	3200		111.980	
	1600		112.000	
	800		112.045	
	400		112.125	
	200		112.265	
	100		112.54	
	liq.			F — 1.65 ₉₂₀
Na ₂ S	c		89.8	S — 15.2 ₄₀₀
	∞	$2Na^+(\infty) + S^{--}(\infty)$		
			104.96	
	1600		104.86	
	800		104.89	
	400		104.96	
	200		105.08	
	100		105.29	
	50		105.64	
	25		106.14	
	20		106.34	
Na ₂ S·4½H ₂ O	c		417.54	S — 4.91 ₄₀₀
Na ₂ S·5H ₂ O	c		453.35	S — 6.54 ₄₀₀
Na ₂ S·9H ₂ O	c		736.94	S — 16.65 ₄₀₀
Na ₂ S ₂	aq.		105.7	
Na ₂ S ₃	aq.		107.2	
Na ₂ S ₄	c		99.8	S — 9.9 ₆₀₀
	aq.		109.7	
Na ₂ SO ₃	c		261.2	S — 2.7 ₈₀₀
	∞	$2Na^+(\infty) + SO_3^{--}(\infty)$		
			264.0	
	800		263.9	
Na ₂ SO ₃ ·7H ₂ O	c		753.7	S — 11.2 ₈₀₀
Na ₂ SO ₄	liq.			F — 8.7 ₈₈₅

Sodium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹	
Na ₂ SO ₄	c		330.48	S	0.26 ₄₀₀
	∞	2Na ⁺ (∞) + SO ₄ ²⁻ (∞)	330.76		
	6400		330.638		
	3200		330.615		
	1600		330.610		
	800		330.633		
	400		330.735		
	200		330.985		
	100		331.450		
	50		332.115		
Na ₂ SO ₄ ·10H ₂ O	c		1033.20	S	18.76 ₄₀₀
Na ₂ S ₂ O ₃	c		258.5	S	2.0 ₄₄₀
	aq.		260.5		
	5		262.5		
Na ₂ S ₂ O ₃ ·5H ₂ O	c	α	613.65	S	11.33 ₄₀₀
	c	β	612.35		
Na ₂ S ₂ O ₅	c		349.0	T	1.3 ^{17.5} _{→s}
	aq.		344.6		
Na ₂ S ₂ O ₆	c		401.0	S	5.82 ₄₀₀
	aq.		395.2		
Na ₂ S ₂ O ₆ ·2H ₂ O	c		543.8	S	11.68 ₄₀₀
Na ₂ S ₃ O ₆	aq.		392.		
Na ₂ S ₃ O ₆ ·3H ₂ O	c		606.7	S	9.6 ₉₈₀
Na ₂ S ₄ O ₆	aq.		387.3		
Na ₂ S ₄ O ₆ ·2H ₂ O	c		533.0	S	9.0 ₆₀₀
NaHS	c		56.76	S	4.59 ₄₀₀
	∞	Na ⁺ (∞) + HS ⁻ (∞)	61.38		
	800		61.33		
	400		61.35		
	200		61.37		
	100		61.43		
	50		61.56		
	25		61.82		
	20		61.94		
	15		62.12		
	12		62.27		
	10		62.37		
	8		62.44		
	6		62.41		
	5		62.28		
	4		61.95		
NaHS·2H ₂ O	c		199.61	S	1.52 ₄₀₀
NaHSO ₃	aq.		206.5		
NaHSO ₄	c		269.04		

Sodium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
NaHSO ₄	800		270.78	
	400		270.56	
	200		270.29	
	100		270.15	
	50		270.12	
	25		270.08	
	20		270.04	
	10		269.62	
NaHSO ₄ ·H ₂ O	c		339.0	<i>S</i> — 0.3
NaI·2SO ₂	c		231.2	<i>D</i> — 10.0
NaI·4SO ₂	c		392.4	<i>D</i> — 9.6
Na ₂ Se	c		59.1	<i>S</i> — 18.8 ₁₀₀₀
	440		77.9	
Na ₂ Se·4½H ₂ O	c		393.4	<i>S</i> — 7.8 ₂₀₀₀
Na ₂ Se·9H ₂ O	c		703.9	<i>S</i> — 10.7 ₂₀₀₀
Na ₂ Se·16H ₂ O	c		1194.1	<i>S</i> — 22.3 ₂₀₀₀
Na ₂ SeO ₃	800		238.2	
Na ₂ SeO ₄	c		254.	
	∞	2Na ⁺ (∞) + SeO ₄ ²⁻ (∞)	261.3	
	800		261.3	
NaHSe	4000		31.0	
NaHSeO ₃	800		182.24	
NaHSeO ₄	400		201.72	
Na ₂ TeO ₄	c		308.	
	aq.		283.9	
NaNO ₂	c		86.6	<i>S</i> — 3.55 ₃₅₀
	aq.		83.0	
NaNO ₃	c		111.72	<i>S</i> — 4.97 ₂₀₀
	∞	Na ⁺ (∞) + NO ₃ ⁻ (∞)	106.669	
	6400		106.639	
	3200		106.635	
	1600		106.638	
	800		106.651	
	400		106.684	
	200		106.755	
	100		106.915	
	50		107.189	
	25		107.629	
	20		107.804	
	18		107.889	
	15		108.049	
	12		108.239	
	10		108.389	
	8		108.564	

Sodium

Formula	State	Description	Q_f , kcal. mole^{-1}	Q , kcal. mole^{-1}
NaNO_3	6		108.794	
	5		109.029	
$\text{Na}_2\text{N}_2\text{O}_2$	aq.		111.5	
NaNH_2	c		32.0	
NaNH_3	c		16.2	
$\text{NaCl} \cdot 5\text{NH}_3$	c		192.2	$D - 7.8$
$\text{NaBr} \cdot 5\frac{1}{2}\text{NH}_3$	c		188.7	$D - 8.5$
$\text{NaBr} \cdot 5\frac{1}{2}\text{NH}_3$	c		197.7	$D - 7.0$
$\text{NaI} \cdot 4\frac{1}{2}\text{NH}_3$	c		161.0	$D - 9.4$
$\text{NaI} \cdot 6\text{NH}_3$	c		188.7	$D - 7.5$
$\text{Na}_2\text{SO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot \text{H}_2\text{O}$	c		690.9	$S - 12.7$
NaPO_3	c		288.7	$S - 4.0$
	600		292.67	
Na_3PO_3	1000		388.81	
Na_3PO_4	c		457.	
	1600		470.0	
	800		471.0	
	400		471.6	
	200		471.9	
$\text{Na}_3\text{PO}_4 \cdot 12\text{H}_2\text{O}$	c		1305.7	$S - 14.26_{600}$
$\text{Na}_4\text{P}_2\text{O}_6$	aq.			$N - 54.2^{11}_{1200}$
$\text{Na}_4\text{P}_2\text{O}_7$	c		755.2	$S - 11.92_{800}$
	1600		767.1	
$\text{Na}_4\text{P}_2\text{O}_7 \cdot 10\text{H}_2\text{O}$	c		1462.5	$S - 11.65_{800}$
NaH_2PO_2	500		200.05	
NaH_2PO_3	c		286.42	$S - 0.90_{550}$
	600		287.32	
$\text{NaH}_2\text{PO}_3 \cdot 2\frac{1}{2}\text{H}_2\text{O}$	c		463.53	$S - 5.26_{550}$
NaH_3PO_4	300		364.64	
$\text{NaH}_3\text{P}_2\text{O}_6$	aq.			$N - 15.1^{11}_{550}$
$\text{NaH}_3\text{P}_2\text{O}_7$	c		596.9	$S - 0.80$
	1200		597.66	
$\text{NaH}_2\text{PO}_4 \cdot \text{H}_3\text{PO}_4$	c		669.7	$S - 1.1$
Na_2HPO_2	800		243.84	
Na_2HPO_3	c		335.33	$S - 9.30_{550}$
	800		344.63	
$\text{Na}_2\text{HPO}_3 \cdot 5\text{H}_2\text{O}$	c		691.02	$S - 4.54_{550}$
Na_2HPO_4	c		414.85	$S - 5.65_{400}$
	1600		420.06	
	800		420.26	
	400		420.5	
	200		420.82	
$\text{Na}_2\text{HPO}_4 \cdot 2\text{H}_2\text{O}$	c		557.62	$S - 0.38_{400}$
$\text{Na}_2\text{HPO}_4 \cdot 7\text{H}_2\text{O}$	c		910.69	$S - 11.60_{400}$
$\text{Na}_2\text{HPO}_4 \cdot 12\text{H}_2\text{O}$	c		1263.68	$S - 22.74_{400}$
$\text{Na}_2\text{H}_2\text{P}_2\text{O}_6$	c		499.67	

Sodium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
$\text{Na}_2\text{H}_2\text{P}_2\text{O}_6$	550		500.07	
$\text{Na}_2\text{H}_2\text{P}_2\text{O}_6$	aq.			<i>N</i> 30.1 ¹¹ ₇₇₀
$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7$	c		657.8	<i>S</i> — 2.2
	1200		655.6	
$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 \cdot 6\text{H}_2\text{O}$	c		1079.8	<i>S</i> — 14.0
$\text{Na}_2\text{HP}_2\text{O}_6$	aq.			<i>N</i> 42.7 ¹¹ ₉₉₀
$\text{Na}_2\text{HP}_2\text{O}_7$	c		706.1	<i>S</i> 6.9
	aq.		713.	
$\text{Na}_2\text{HP}_2\text{O}_7 \cdot \text{H}_2\text{O}$	c		780.2	<i>S</i> 1.2
$\text{Na}_2\text{HP}_2\text{O}_7 \cdot 6\text{H}_2\text{O}$	c		1130.2	<i>S</i> — 7.0
$\text{NaNH}_4\text{HPO}_4$	550		372.3	
$\text{NaNH}_4\text{HPO}_4 \cdot 4\text{H}_2\text{O}$	c		656.6	<i>S</i> — 10.8 ₈₀₀
$\text{Na}_2\text{NH}_4\text{PO}_4$	550		440.7	
$\text{Na}(\text{NH}_4)_2\text{PO}_4$	660		399.3	
Na_2AsO_3	500		314.30	
Na_2AsO_4	c		366.	
	500		381.65	
$\text{Na}_2\text{AsO}_4 \cdot 12\text{H}_2\text{O}$	c		1214.7	<i>S</i> — 12.6 ₀₆₀
NaH_2AsO_3	400		225.89	
NaH_2AsO_4	300		273.23	
Na_2HASO_3	400		270.31	
Na_2HASO_4	400		329.56	
Na_2SbO_4	c		349.	
	aq.		360.	
$3\text{Na}_2\text{S} \cdot \text{Sb}_2\text{S}_3$	aq.		394.	
Na_2BiO_4	c		284.	
Na_2C_2	c		— 4.1	
Na_2CO_3	liq.			<i>F</i> — 9.1 ₈₈₀
	c	I		<i>T</i> 0.4 ⁴⁸⁰ → 11
	c	II	269.89	<i>S</i> 5.88 ₈₀₀
	∞	$2\text{Na}^+(\infty) + \text{CO}_3^{--}(\infty)$	275.46	
	6400		275.37	
	3200		275.36	
	1600		275.36	
	800		275.40	
	400		275.52	
	200		275.77	
	100		276.19	
	50		276.83	
	25		277.59	
	20		277.83	
	18		277.94	
	15		278.13	
$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$	c		341.64	<i>S</i> 2.50 ₈₀₀
$\text{Na}_2\text{CO}_3 \cdot 7\text{H}_2\text{O}$	c		764.86	<i>S</i> — 10.50 ₈₀₀

Sodium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
$Na_2CO_3 \cdot 10H_2O$	c		975.38	<i>S</i> — 15.91 ₂₀₀
$Na_2C_2O_4$	c	sodium oxalate	314.7	<i>S</i> — 4.1 ₄₀₀
	600		310.58	
$NaHC_2O_4$	c		— 25.1	
$NaCHO_2$	c	sodium formate	157.7	<i>S</i> — 0.41 ₁₈₀
	400		157.29	
$NaHCO_3$	c	sodium bicarbonate	226.4	<i>S</i> — 4.1 ₂₀₀
	1800		222.3	
$NaCH_3O$	60 CH_3OH		105.5	
$NaHC_2O_4$	c	sodium bioxalate	257.7	<i>S</i> — 5.3 ₄₀₀
	400		252.43	
$NaHC_2O_4 \cdot H_2O$	c		330.1	<i>S</i> — 9.3 ₄₀₀
$NaC_2H_3O_2$	c	sodium acetate	171.34	<i>S</i> — 3.90 ₂₀₀
	∞	$Na^+(\infty) + C_2H_3O_2^-(\infty)$	175.425	
	6400		175.382	
	3200		175.363	
	1600		175.340	
	800		175.310	
	400		175.275	
	200		175.237	
	100		175.192	
	50		175.143	
	25		175.065	
	20		175.025	
	15		174.954	
	12		174.845	
	10		174.735	
	8		174.575	
	6		174.335	
	5		174.175	
	4		173.985	
	3		173.725	
	1100 C_2H_5OH		172.64	
$NaC_2H_3O_2 \cdot 3H_2O$	c		385.20	<i>S</i> — 4.85 ₂₀₀
$NaC_2H_3O_2$	c	glycollate	216.0	<i>S</i> — 2.46
	aq.		213.5	<i>N</i> — 13.6
$NaC_2H_3O_2 \cdot \frac{1}{2}H_2O$	c		251.2	<i>S</i> — 3.5
NaC_2H_5O	60 C_2H_5OH	in ethyl alcohol	111.9	
$NaC_2H_5O_2$	c	sodium glycol	150.1	
	aq.		156.1	
$NaC_2H_5O_2$	c	sodium methanol glycol	215.4	<i>S</i> — 1.97
	aq.		213.4	

Sodium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
$\text{Na}_2\text{C}_2\text{H}_3\text{O}_3$	c	bisodium glycollate	248.9	<i>S</i> 9.18
	aq.		258.1	
$\text{Na}_2\text{C}_2\text{H}_3\text{O}_3 \cdot 2\text{H}_2\text{O}$	c		395.2	<i>S</i> — 0.36
$\text{Na}_2\text{C}_2\text{H}_3\text{SO}_4$	aq.	sodium ethyl sulfate	265.3	
$\text{Na}_2\text{S}_2\text{O}_3 \cdot \text{C}_2\text{H}_3\text{O}_2$	aq.	sodium glyoxal metabisulfite	594.8	
$\text{Na}_2\text{S}_2\text{O}_3 \cdot \text{C}_2\text{H}_3\text{O}_2 \cdot 2\text{H}_2\text{O}$	c		741.2	<i>S</i> — 9.66
NaCN	c		22.95	<i>S</i> — 0.37 ₁₀₀
	200		22.58	
$\text{NaCN} \cdot \frac{1}{2}\text{H}_2\text{O}$	c		57.68	<i>S</i> — 0.91 ₁₀₀
$\text{NaCN} \cdot 2\text{H}_2\text{O}$	c		163.73	<i>S</i> — 4.41 ₁₀₀
NaCNO	c		96.7	<i>S</i> — 4.70 ₁₀₀₀
	aq.		92.0	
NaCN_2H	aq.		35.0	
$\text{Na}_2\text{C}_2\text{H}_4\text{NO}_2$	c	sodium glycine	169.5	<i>N</i> 3.0
NaCNS	c		40.36	<i>S</i> — 1.80 ₂₀₀
	∞	$\text{Na}^+(\infty) + \text{CNS}^-(\infty)$	38.53	
	6400		38.500	
	3200		38.490	
	1600		38.490	
	800		38.495	
	400		38.520	
	200		38.565	
	100		38.665	
	50		38.83	
	25		39.17	
	20		39.29	
	15		39.50	
	12		39.65	
	10		39.77	
	8		39.90	
	6		40.02	
	5		40.06	
	4		40.05	
	3		39.90	
$\infty \text{C}_2\text{H}_5\text{OH}$		in ethyl alcohol	39.16	
200 $\text{C}_2\text{H}_5\text{OH}$			39.24	
100 $\text{C}_2\text{H}_5\text{OH}$			39.33	
50 $\text{C}_2\text{H}_5\text{OH}$			39.49	
10 $\text{C}_2\text{H}_5\text{OH}$			41.12	
8.38 $\text{C}_2\text{H}_5\text{OH}$			41.43	

Sodium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Na ₂ SiO ₃	gls.		374.	
	c		371.2	
Na ₂ SiF ₆	c		669.	
	660		659.0	
NaHSiF ₆	400		601.9	
NaSn	c		16.	
NaSn ₂	c		20.	
Na ₂ Sn	c		21.	
Na ₄ Sn	c		34.	
Na ₄ Sn ₃	c		56.	
Na ₂ SnO ₃	c	(?)	273.	
Na ₄ SnO ₄	aq.		453.6	
Na ₂ PbO ₃	c		202.4	
2NaI·PbI ₂	c		104.49	S 79.04 ₁₇₀₀
2NaI·PbI ₂ ·4H ₂ O	c		481.94	
2NaI·PbI ₂ ·6H ₂ O	c		621.46	
2Na ₂ S ₂ O ₃ ·PbS ₂ O ₃	c		676.7	S — 3.8 ₂₇₀₀
	aq.		672.9	
Na ₂ ZnO ₂	c		187.	
Na ₂ Zn(SO ₄) ₂	c		567.0	S 15.9 ₃₈₀
Na ₂ Zn(SO ₄) ₂ ·4H ₂ O	c		866.6	S — 0.2 ₃₈₀
NaCd ₂	c		8.5	
NaCd ₃	c		12.5	
Na ₂ CdO ₂	c		164.	
NaHg _{27.5}	liq.		19.75	
NaHg ₅₀	liq.		19.91	
NaHg ₁₀₀	liq.		20.0	
NaHg ₂₀₀	liq.		20.05	
NaHg ₄₀₀	liq.		20.07	
NaHg ₁	c		3.7	
NaHg ₃	c		7.4	
NaHg	c		11.0	
NaHg ₂	c		18.5	
NaHg ₄	c		22.2	
NaBr·HgBr ₂	4600		125.73	
2NaBr·HgBr ₂	4700		212.90	
4NaBr·HgBr ₂	5000		386.79	
8NaBr·HgBr ₂	5900		727.34	
4Na ₂ S·HgS	aq.		538.9	
NaCN·Hg(CN) ₂	550	—	35.12	
2NaCN·Hg(CN) ₂	660	—	7.19	
NaCl·Hg(CN) ₂	550		32.49	
2NaCl·Hg(CN) ₂	660		129.69	
NaCl·Hg(CN) ₂ ·1½H ₂ O	c		125.90	S — 7.95
NaBr·Hg(CN) ₂	550		21.89	

Sodium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
2NaBr·Hg(CN) ₂	660		108.37	
NaBr·Hg(CN) ₂ ·2H ₂ O	c		170.53	S — 11.90
NaI·Hg(CN) ₂	550		8.76	
2NaI·Hg(CN) ₂	660		80.84	
NaI·Hg(CN) ₂ ·2H ₂ O	c		156.80	S — 11.30
Na ₂ O·CuO ₂	c		168.	
Na ₂ CO ₃ ·CuCO ₃	c		418.5	
Na ₂ CO ₃ ·CuCO ₃ ·3H ₂ O	c		632.91	
Na ₂ O·Ag ₂ O ₂	c		146.	
Na ₂ Ag(S ₂ O ₃) ₂	aq.		459.	
NaCN·AgCN	550		— 4.2	
2NaCN·AgCN	220		20.2	
	330		19.8	
	1320		18.9	
Na ₂ PtCl ₄	aq.		237.0	
Na ₂ PtCl ₆	c		272.1	S 8.49 ₈₀₀
	aq.		280.6	
Na ₂ PtCl ₆ ·2H ₂ O	c		417.4	S — 0.10 ₆₆₇
Na ₂ PtCl ₆ ·6H ₂ O	c		701.4	S — 10.57 ₉₀₀
Na ₂ PtBr ₄	aq.		205.2	S 9.94 ¹⁸ .7 ₈₀₀
Na ₂ PtBr ₆	c		221.3	
	aq.		231.2	
Na ₂ PtBr ₆ ·6H ₂ O	c		649.9	S — 8.51 ¹⁹ ₈₀₀
Na ₂ PtI ₆	aq.		167.4	
Na ₂ IrCl ₆	aq.		267.5	
Na ₂ IrCl ₆	aq.		359.2	
Na ₂ PdCl ₄	aq.		242.5	
Na ₂ PdCl ₆	aq.		271.5	
Na ₂ PdBr ₄	aq.		200.5	
Na ₂ RhCl ₆	c		370.1	S 7.83 ¹⁹ ₈₀₀₀
	aq.		377.9	
Na ₂ RhCl ₆ ·12H ₂ O	c		1218.9	S — 20.56 ¹⁷ ₆₅₀₀
2NaCN·Ni(CN) ₂	aq.		34.4	
Na ₂ CoO ₃	c		200.	
2NaBr·CoBr ₂	440		245.83	
Na ₂ FeCO(CN) ₅	c		124.3	S 5.2 ₃₉₀₀
	aq.		129.5	
Na ₂ FeCO(CN) ₅ ·7H ₂ O	c		615.5	S — 7.4 ₂₇₀₀
Na ₂ MnO ₄	c		270.	
2NaBr·MnBr ₂	440		278.34	
Na ₂ SO ₄ ·MnSO ₄	c		583.6	S 12.8 ₁₈₀
Na ₂ SO ₄ ·MnSO ₄ ·2H ₂ O	c		730.1	S 3.1 ₁₈₀
Na ₂ CrO ₄	c		319.8	S 2.50 ₈₀₀
	800		322.3	
	10		323.3	
Na ₂ CrO ₄ ·4H ₂ O	c		603.3	S — 7.50 ₄₈₀

Sodium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
Na ₂ CrO ₄ ·10H ₂ O	c		1022.0	<i>S</i> — 16.0 ₇₇₀
Na ₂ Cr ₂ O ₇	1200		465.6	
Na ₂ MoO ₄	c	I		<i>T</i> 14.6 ⁴⁴⁰ → ₁₁
	c	II	364.	
	aq.		358.5	
Na ₂ WO ₄	c	I		<i>T</i> 9.5 ⁵⁷⁹ → ₁₁
	c	II	391.	
	aq.		381.3	
Na ₂ UO ₄	c		500.	
Na ₂ U ₂ O ₇ ·1½H ₂ O	c		856.	
(Na ₂ O ₂) ₂ UO ₄	aq.		584.	
(Na ₂ O ₂) ₂ UO ₄ ·9H ₂ O	c		1213.	
NaVO ₃	aq.		315.1	
NaVO ₄	aq.		301.4	
NaVO ₃	aq.		287.4	
Na ₂ VO ₄	c		450.	
2NaCl·ThCl ₄	c		535.7	<i>S</i> 50.6
NaCl·ThCl ₄ ·10H ₂ O	c		1178.4	<i>S</i> — 5.5
NaBO ₂	300		231.7	
NaBO ₃	aq.		257.1	
NaBO ₃ ·4H ₂ O	c		542.1	<i>S</i> — 11.56
Na ₂ B ₄ O ₇	c		742.6	<i>S</i> 10.
	900		752.6	
Na ₂ B ₄ O ₇ ·10H ₂ O	c		1453.1	<i>S</i> — 25.8 ₁₀₀₀
Na ₂ BO ₃	c		(?) 341.	
	600		387.7	
NaAlO ₂	c		272.	
3NaF·AlF ₃	liq.			<i>F</i> — 16.64
	c	I		<i>T</i> 1.24 _{→11}
	c	II	758.47	
	3300		767.80	
3NaF·AlF ₃ ·3½H ₂ O	c		1020.04	
NaCl·AlCl ₃	c		270.5	<i>S</i> 71.31 ₈₈₀
NaCl·AlCl ₃ ·6NH ₃	c		461.4	<i>S</i> 6.2
3NaCl·AlCl ₃	c		470.4	<i>S</i> 65.65 ₁₃₃₀
3NaCl·2AlCl ₃	c		642.4	<i>S</i> 138.28 ₂₀₀₀
Na ₂ O·Al ₂ O ₃ ·3SiO ₂	c	natrolite	1179.9	
Na ₂ O·Al ₂ O ₃ ·4SiO ₂	c	dehydrated analcite	1365.9	
Na ₂ SO ₄ ·CaSO ₄	c		674.2	
2Na ₂ SO ₄ ·CaSO ₄ ·2H ₂ O	c		1144.7	
NaSrPO ₄ ·9H ₂ O	c		1117.7	
NaSrAsO ₄ ·9H ₂ O	c		1026.0	
NaBaPO ₄ ·9H ₂ O	c		1116.3	
NaBaAsO ₄ ·9H ₂ O	c		1024.7	
NaLiCl	c	fresh melt	166.4	

Potassium

Atomic number 19

Standard state K (c)

Atomic weight 39.096

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
K	g	4s ($^2S_{1/2}$)	- 19.80	
	liq.			F - 0.574 ²⁶
	c		0.000	
K*	g	4p ($^2P_{1/2}$)	- 56.40	E° - 36.596
	g	($^2P_{3/2}$)	- 56.90	E° - 37.102
K ⁺	g	3p ⁶ (1S_0)	- 120.90	I° - 99.654
	∞		60.270	
K ⁺⁺	g	3p ⁵ ($^2P_{3/2}$)	- 852.94	I° - 730.59
K ⁺⁺ *	g	($^2P_{1/2}$)	- 859.10	E° - 6.16
	g	3s3p ⁶ ($^3S_{1/2}$)	-1230.9	E° - 371.8
K ⁺⁺⁺	g	3p ⁴ (3P_2)	-1927.4	I° -1073.
K ₂	g	A $^1\Sigma^+_g$	- 27.0	
K ₂ *	g	B $^1\Sigma^+_g$	- 60.2	E° - 33.2
	g	C $^1\Pi_u$	- 70.8	E° - 43.8
K ₂ O	c		86.2	
K ₂ O ₂	c		126.	
K ₂ O ₄	c		135.	
KH	c		10.	
KOH		I		T 1.52 ²⁴⁸ ± 11
	c	II	102.02	S 12.78 ₁₀₀
	∞	K ⁺ (∞) + OH ⁻ (∞)	114.930	
	6400		114.892	
	3200		114.878	
	1600		114.860	
	800		114.840	
	400		114.817	
	200		114.8	
	100		114.793	
	50		114.793	
	25		114.768	
	20		114.76	
	15		114.70	
	12		114.57	
	10		114.52	
	8		114.32	
	6		113.90	
	5		113.56	
	4		112.99	
	3		112.10	
KOH· $\frac{1}{2}$ H ₂ O	c		161.94	S 4.14 ₂₀₀
KOH·H ₂ O	c		179.82	S 3.35 ₂₀₀
KOH·2H ₂ O	c		250.81	S 0.13 ₂₀₀
KF	g		84.3	V - 38.4 ¹¹⁰⁰

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
KF	liq.			$F - 6.3^{860}$
	c		134.51	$S - 3.85_{200}$
	∞	$K^+(\infty) + F^-(\infty)$	138.470	
	6400		138.436	
	3200		138.423	
	1600		138.408	
	800		138.389	
	400		138.370	
	200		138.355	
	100		138.349	
	50		138.347	
	25		138.339	
	20		138.338	
	15		138.325	
	12		138.295	
	10		138.248	
	8		138.155	
	6		137.920	
	5		137.690	
	4		137.295	
	3		136.73	
KF·2H ₂ O	c		277.06	$S - 1.96_{200}$
KF·4H ₂ O	c		418.00	$S - 6.16_{200}$
KHF ₂	c		219.43	$S - 5.98_{400}$
	∞	$K^+(\infty) + HF_2^-(\infty)$	213.67	
	3200		213.62	
	1600		213.60	
	800		213.57	
	400		213.535	
	200		213.505	
	100		213.515	
	50		213.615	
	25		213.870	
	c		297.0	$S - 8.0$
	c		373.2	$S - 8.6$
	g		52.4	
	liq.			$F - 6.4^{700}$
KCl	c		104.361	$S - 4.449_{200}$
	∞	$K^+(\infty) + Cl^-(\infty)$	99.957	
	6400		99.924	
	3200		99.915	
	1600		99.906	

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
KCl	800		99.899	
	400		99.899	
	200		99.912	
	100		99.970	
	50		100.085	
	25		100.275	
	20		100.359	
	15		100.483	
	12		100.575	
KClO	800		86.2	
KClO ₃	c		91.33	S - 10.17 ₄₀₀
	∞	K ⁺ (∞) + ClO ₃ ⁻ (∞)	81.020	
	6400		81.003	
	3200		81.003	
	1600		81.013	
	800		81.06	
	400		81.16	
	200		81.36	
	100		81.78	
	c		112.71	
KClO ₄	∞	K ⁺ (∞) + ClO ₄ ⁻ (∞)	99.77	S - 12.28 ₈₀₀
	1600		100.14	
	800		100.43	
	400		100.97	
	200		101.83	
	c		44.0	
KBr	c		94.07	S - 5.10 ₈₀₀
	∞	K ⁺ (∞) + Br ⁻ (∞)	88.940	
	6400		88.912	
	3200		88.907	
	1600		88.904	
	800		88.906	
	400		88.923	
	200		88.971	
	100		89.060	
	50		89.215	
	25		89.472	
	20		89.580	
	15		89.742	
	12		89.883	
	10		90.014	
	aq.		91.4	
KBr ₃				

Potassium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
KBrO	aq.		81.6	
KBrO ₃	c		81.60	<i>S</i> — 10.0 ₄₀₀
	∞	K ⁺ (∞) + BrO ₃ ⁻ (∞)	71.47	
	6400		71.456	
	3200		71.460	
	1600		71.475	
	800		71.52	
	400		71.63	
	200		71.84	
KI	g		30.0	<i>V</i> — 37.6 ¹⁰⁰⁰
	c		78.87	<i>S</i> — 5.19 ₂₀₀
	∞	K ⁺ (∞) + I ⁻ (∞)	73.640	
	6400		73.612	
	3200		73.607	
	1600		73.605	
	800		73.609	
	400		73.630	
	200		73.677	
	100		73.772	
	50		73.955	
	25		74.281	
	20		74.425	
	15		74.647	
	10		75.004	
	8		75.210	
	6		75.485	
	200 CH ₃ OH	in methanol	78.12	<i>S</i> — 0.75 ^{18.5} ₂₀₀ CH ₃ OH
	200 C ₂ H ₅ OH	in ethanol	76.67	<i>S</i> — 2.20 ^{17.6} ₂₀₀ C ₂ H ₅ OH
	400 C ₃ H ₇ OH		76.88	<i>S</i> — 1.99 ^{17.1} ₄₀₀ C ₃ H ₇ OH
	590 C ₂ H ₅ OH		77.33	<i>S</i> — 1.54 ^{4.80} C ₂ H ₅ OH
	200 CH ₃ CN	in acetonitrile	76.2	<i>S</i> — 2.7 ₂₀₀ CH ₃ CN
	475 CH ₃ CN		76.0	<i>S</i> — 2.9 ⁴⁷⁵ CH ₃ CN
	200 C ₃ H ₈ O	in acetone	83.06	
KI ₂	c		78.9	
	aq.		72.4	
KIO ₃	c		121.70	<i>S</i> — 6.70 ₄₀₀
	∞	K ⁺ (∞) + IO ₃ ⁻ (∞)	114.770	
	6400		114.765	
	3200		114.780	
	1600		114.810	
	800		114.880	
	400		114.995	

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
KIO ₃	200		115.19	
	100		115.59	
KIO ₄	aq.		97.9	
K ₃ IO ₆	aq.		283.7	
KH ₄ IO ₆	aq.		234.6	
KIO ₃ ·HIO ₃	c		181.0	S — 11.3 ₈₇₀
	1600		169.67	
K ₂ H ₃ IO ₆	aq.		302.5	
K ₃ H ₂ IO ₆	aq.		352.1	
KI·KCl	c	fresh melt	182.69	
K ₂ S	c		121.5	S 11.
	∞	2K ⁺ (∞) + S ²⁻ (∞)	110.54	
	400		110.54	
	200		110.58	
	100		110.67	
	50		110.84	
	25		110.97	
	20		110.91	
	15		110.64	
	12		110.27	
	10		109.78	
	8		108.97	
	7		108.24	
K ₂ S·2H ₂ O	c		243.46	S 3.8 ₁₆₀₀
K ₂ S·5H ₂ O	c		457.53	S — 5.16 ₉₀₀
K ₂ S _{3/4}	c		112.0	S 3.2 ₁₂₀₀
	aq.		115.2	
K ₂ S ₄	c		114.1	S 1.34 ₁₁₄₀
	aq.		115.4	
K ₂ S ₄ · $\frac{1}{2}$ H ₂ O	c		151.5	S — 1.9
K ₂ S ₄ ·2H ₂ O	c		259.4	S — 7.3
K ₂ SO ₃	c		267.7	S 1.8 ₃₅₀
	aq.		269.5	
K ₂ SO ₃ ·H ₂ O	c		336.5	S 1.4 ₂₅₀
K ₂ SO ₄	c	I		T 2.57 ₅₆₉ → II
	c	II	342.66	S — 6.42 ₄₀₀
	∞	2K ⁺ (∞) + SO ₄ ²⁻ (∞)	336.340	
	6400		336.210	
	3200		336.183	
	1600		336.169	
	800		336.175	
	400		336.237	
	200		336.450	

Potassium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
K ₂ SO ₄	100		336.970	
K ₂ S ₂ O ₈	c		270.5	<i>S</i> — 4.5 ₁₀₀₀
	aq.		266.0	
K ₂ S ₂ O ₅	c		361.1	<i>S</i> — 11.0 ₅₀₀
	aq.		350.1	
K ₂ S ₂ O ₅ ·½H ₂ O	c		394.5	<i>S</i> — 10.2 ₅₀₀
K ₂ S ₂ O ₅	c		413.7	<i>S</i> — 13.0 ₅₀₀
	aq.		400.7	
K ₂ S ₂ O ₇	c		475.4	<i>S</i> — 3.8 ₅₀₀
	aq.		471.6	
K ₂ S ₂ O ₈	c		457.5	<i>S</i> — 13.7 ₃₃₀₀
	aq.		443.8	
K ₂ S ₃ O ₆	c		411.2	<i>S</i> — 12.40 ₆₀₀
	aq.		398.8	
K ₂ S ₄ O ₆	c		406.0	<i>S</i> — 13.18 ₅₀₀
	aq.		392.8	
K ₂ S ₅ O ₆	c		398.	
	aq.		390.	
K ₂ S ₅ O ₆ ·1½H ₂ O	c		505.2	<i>S</i> — 12.6 ₂₀₀₀
KHS	c		63.31	<i>S</i> 0.80 ₄₀₀
	∞	K ⁺ (∞)+ HS ⁻ (∞)	64.17	
	400		64.11	
	200		64.12	
	100		64.14	
	50		64.21	
	25		64.35	
	20		64.41	
	15		64.50	
	12		64.57	
	10		64.62	
	8		64.67	
	6		64.69	
	5		64.64	
	4		64.52	
	3		64.24	
KHS·½H ₂ O	c		80.58	<i>S</i> 0.62 ₄₀₀
KHSO ₃	aq.		209.3	
KHSO ₄	c	I		<i>T</i> 0.49 ¹⁸⁰ →II
	c	II		<i>T</i> 0.096 ¹⁶⁴ →III
	c	III	276.85	<i>S</i> — 3.75 ₂₀₀
	800		273.75	
	400		273.37	
	200		273.1	
	100		272.97	

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
KHSO ₄	50		272.94	
	25		272.99	
	20		272.02	
KI·4SO ₂	c		401.4	D — 9.7
K ₂ Se	c		74.4	S — 8.8 ₁₈₀₀
	aq.		83.2	
K ₂ Se·9H ₂ O	c		717.7	S — 19.2 ₃₀₀₀
K ₂ Se·14H ₂ O	c		1061.0	S — 20.6 ₄₀₀₀
K ₂ Se·19H ₂ O	c		1411.9	S — 29.7 ₃₄₀₀
K ₂ SeO ₄	∞	2K ⁺ (∞) + SeO ₄ ²⁻ (∞)	266.9	
	440		266.85	
KHSe	aq.		34.0	
KHSeO ₄	220		204.4	
K ₂ TeO ₃	aq.		261.6	
K ₂ TeO ₄	220		289.4	
KNO ₂	aq.		85.8	
KNO ₃	liq.			F — 2.57 ³³³
	c	I		T — 1.17 ¹²⁸ → II
	c	II		T — 0.62 ¹²⁶ → III
	c	III	118.093	S — 8.400 ₂₀₀
	∞	K ⁺ (∞) + NO ₃ ⁻ (∞)	109.460	
	6400		109.429	
	3200		109.431	
	1600		109.442	
	800		109.477	
	400		109.550	
	200		109.693	N — 14.165 ₂₀₁
	100		109.925	
	50		110.345	
	25		110.99	
	20		111.26	
K ₂ N ₂ O ₂	aq.		117.0	
KNH ₃	c		17.4	D — 6.4
KBr·4NH ₃	c		166.6	D — 7.15
KI·4NH ₃	c		153.4	D — 7.65
KI·6NH ₃	c		190.0	D — 7.35
KPO ₃	aq.		295.5	
K ₃ PO ₃	aq.		397.2	
K ₃ PO ₄	aq.		478.4	
KH ₂ PO ₂	aq.		202.8	
KH ₂ PO ₃	aq.		290.1	
KH ₂ PO ₄	c		362.7	S — 4.7 ₁₈₀
	aq.		367.4	

Potassium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
KH ₂ PO ₄	aq.		600.5	
K ₂ HPO ₄	aq.		249.4	
K ₂ HPO ₃	aq.		350.2	
K ₂ HPO ₄	aq.		425.6	
K ₂ H ₂ P ₂ O ₅	aq.		505.7	
K ₂ H ₂ P ₂ O ₇	aq.		661.1	
K ₂ HP ₂ O ₇	aq.		721.4	
K ₂ P ₂ O ₇	aq.		778.3	
KH ₂ AsO ₃	aq.		228.7	
KH ₂ AsO ₄	c		271.2	<i>S</i> 4.8 ₈₀₀
	aq.		276.0	
K ₂ HAsO ₃	aq.		275.9	
K ₂ HAsO ₄	aq.		335.1	
K ₂ AsO ₃	aq.		322.7	
K ₂ AsO ₄	aq.		390.0	
K ₂ SbO ₄	aq.		368.4	
K ₂ CO ₃	liq.			<i>F</i> — 6.4 ₈₈₀
	c		274.46	<i>S</i> 6.63 ₄₀₀
	∞	2K ⁺ (∞) + CO ₃ ²⁻ (∞)	281.04	
	6400		280.980	
	3200		280.980	
	1600		280.985	
	800		281.010	
	400		281.090	
	200		281.240	
	100		281.440	
	50		281.660	
	25		281.815	
	20		281.860	
	15		281.875	
	10		281.840	
K ₂ CO ₃ ·½H ₂ O	c		310.97	<i>S</i> 4.31 ₄₀₀
K ₂ CO ₃ ·1½H ₂ O	c		384.03	<i>S</i> — 0.38 ₄₀₀
K ₂ C ₂ O ₄	c	potassium oxalate		
	400		320.8	<i>S</i> — 4.56 ₄₀₀
	c		316.2	
K ₂ C ₂ O ₄ ·H ₂ O	c		392.1	<i>S</i> — 7.52 ₈₀₀
5(K ₂ CO ₃ ·1½H ₂ O)·4KHCO ₃	c		2836.	
KCHO ₂	c	potassium formate		
	aq.		160.7	<i>S</i> — 0.66 ₃₂₀
	c		160.0	
KHCO ₃	c	potassium bicarbonate		
	2000		230.2	<i>S</i> — 5.2
			225.07	

Potassium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>	
KCH ₃ O	60 CH ₃ OH		108.5		
KHC ₂ O ₄	aq.	potassium bioxalate	255.3		
KC ₂ H ₃ O ₂	c	potassium acetate	174.67	S	3.35 ₂₀₀
	∞	K ⁺ (∞) + C ₂ H ₃ O ₂ ⁻ (∞)	178.216		
	6400		178.178		
	3200		178.163		
	1600		178.143		
	800		178.114		
	400		178.074		
	200		178.023		
	100		177.951		
	50		177.844		
	25		177.686		
	20		177.616		
	15		177.494		
	12		177.369		
	10		177.241		
	8		177.054		
	6		176.721		
	5		176.451		
KC ₂ H ₃ O ₃	c	potassium glycollate	218.0	S —	1.64
	aq.		216.3	N	13.7
KC ₂ H ₃ O ₃ · ½H ₂ O	c		255.2	S —	4.7
KC ₂ H ₃ O	200 C ₂ H ₅ OH		117.0		
K ₂ S ₂ O ₅ · C ₂ H ₃ O ₂	aq.	potassium glyoxal metabisulfite	363.4		
K ₂ S ₂ O ₅ · C ₂ H ₃ O ₂ · H ₂ O	c		445.2	S —	13.40
KCN	c		28.5	S —	3.0
	200		25.50		
	63		25.58		
KCNO	c		100.0	S —	5.24 ₄₄₀
	aq.		94.8		
	aq.		37.8		
KCN · H	aq.	pseudo salt of nitrometh- ane	80.3	N	7.0
KCNH ₂ O ₂	aq.				
KC ₂ NH ₂ O ₂	c	potassium oxamate	221.0	S —	7.0 ¹²
	aq.		214.0	N	13.65
KCNS	c		47.40	S —	6.00 ₂₀₀

Potassium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
KCNS	∞	$K^+(\infty) +$ $CNS^-(\infty)$	41.320	
	6400		41.290	
	3200		41.280	
	1600		41.285	
	800		41.300	
	400		41.330	
	200		41.400	
	100		41.520	
	50		41.73	
	25		42.09	
	20		42.26	
	15		42.49	
	10		42.86	
	8		43.10	
	6		43.42	
	5		43.63	
	4		43.89	
	3		44.17	
	2		44.50	
KCNS· $\frac{1}{2}$ SO ₂	c		83.4	<i>D</i> — 11.3
KCNS·SO ₂	c		118.8	<i>D</i> — 9.9
K ₂ SiF ₆	c		681.	
	aq.		664.5	
K ₂ SnCl ₆	c		360.21	<i>S</i> — 3.30 ₄₀₀
	600		356.91	
K ₂ SnCl ₄ ·H ₂ O	c		363.2	<i>S</i> — 13.46 ₆₀₀
KCl·PbCl ₂ · $\frac{1}{3}$ H ₂ O	c		214.17	
KCl·2PbCl ₂	c		277.92	
2KI·PbI ₂	c		200.05	<i>S</i> — 10.98 ₁₇₆₀
2KI·PbI ₂ ·2H ₂ O	c		341.41	<i>S</i> — 15.61 ₁₈₀₀
4KI·3PbI ₂	c	fresh melt	439.18	<i>S</i> — 19.23 ₄₅₀₀
4KI·3PbI ₂ ·6H ₂ O	c		861.76	<i>S</i> — 31.61 ₄₈₀₀
K ₂ SO ₄ ·PbSO ₄	c		566.46	
KCl·ThCl ₄ ·9H ₂ O	c		1103.9	<i>S</i> 3.30
2KCl·ThCl ₄	c		552.13	<i>S</i> 39.67
K ₂ Zn(SO ₄) ₂	c		580.31	<i>S</i> 7.98 ₆₀₀
K ₂ Zn(SO ₄) ₂ ·2H ₂ O	c		724.47	<i>S</i> 0.56 ₆₀₀
K ₂ Zn(SO ₄) ₂ ·6H ₂ O	c		1010.48	<i>S</i> — 11.97 ₆₀₀
2KCN·Zn(CN) ₂	c		49.8	<i>S</i> — 15.0 ₄₀₀
KHg	c		11.0	
KHg ₃	c		26.0	
KHg ₁₀	c		33.0	
KHg ₁₀₀	liq.		26.0	
KCl·HgCl ₂	c		160.02	<i>S</i> — 9.5 ₇₇₀

Potassium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
KCl·HgCl ₂	550		150.50	
KCl·HgCl ₂ ·H ₂ O	c		230.22	S — 11.35 ₈₀₀
KCl·2HgCl ₂	990		200.53	
2KCl·HgCl ₂	c		265.70	S — 14.88 ₉₂₀
	300		251.92	
	660		250.82	
2KCl·HgCl ₂ ·H ₂ O	c		335.67	S — 16.48 ₈₀₀
4KCl·HgCl ₂	880		451.20	
4KCl·3HgCl ₂	c		585.30	S — 33.52
	1760		551.78	
4KCl·3HgCl ₂ ·3H ₂ O	c		796.09	S — 39.2
KBr·HgBr ₂	c		134.52	
	4600		128.58	
KBr·HgBr ₂ ·H ₂ O	c		206.23	
2KBr·HgBr ₂	c		230.12	
	4800		128.64	
	300		220.34	
4KBr·HgBr ₂	4800		398.55	
6HBr·HgBr ₂	5000		576.94	
8KBr·HgBr ₂	5900		755.66	
KI·HgI ₂	c		106.36	
KI·HgI ₂ ·H ₂ O	c		174.55	
2KI·HgI ₂	c		185.99	S — 9.88 ₉₂₀
	900		176.11	
3KI·HgI ₂	330		250.84	
4KI·HgI ₂	440		325.02	
6KI·HgI ₂	660		473.58	
KCN·Hg(CN) ₂	550	—	32.2	
KCN·2Hg(CN) ₂	990	—	96.8	
2KCN·Hg(CN) ₂	c		12.4	S — 13.8 ₈₅₀
	660	—	1.4	
4KCN·Hg(CN) ₂	880		49.9	
8KCN·Hg(CN) ₂	1320		152.1	
16KCN·Hg(CN) ₂	2200		356.4	
KCl·Hg(CN) ₂	c		44.1	S — 8.8 ₇₂₀
	550		35.3	
KCl·Hg(CN) ₂ ·H ₂ O	c		114.0	S — 10.3 ₇₆₀
KCl·2Hg(CN) ₂	1000	—	29.4	
2KCl·Hg(CN) ₂	660		135.4	
4KCl·Hg(CN) ₂	880		335.6	
8KCl·Hg(CN) ₂	1320		735.6	
KBr·Hg(CN) ₂	c		36.36	S — 11.6
	550		24.76	
KBr·Hg(CN) ₂ ·1½H ₂ O	c		139.82	
KBr·2Hg(CN) ₂	1000	—	39.95	

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
2KBr·Hg(CN) ₂	660		114.14	
4KBr·Hg(CN) ₂	880		292.78	
8KBr·Hg(CN) ₂	1320		649.62	
KI·Hg(CN) ₂	c		23.6	S — 11.9
	550		11.7	
KI·Hg(CN) ₂ · $\frac{1}{2}$ H ₂ O	c		41.1	
KI·2Hg(CN) ₂	1000		— 52.8	
2KI·Hg(CN) ₂	660		86.56	
4KI·Hg(CN) ₂	880		234.92	
8KI·Hg(CN) ₂	1320		530.44	
KCl·CuCl ₂	c		162.4	
2KCl·CuCl	c		244.78	
2KCl·CuCl ₂	c		266.2	
2KCl·CuCl ₂ ·2H ₂ O	c		407.5	
K ₂ Cu(SO ₄) ₂	c	α , prepared below 130°	527.0	S 9.67 ₈₀₀
	c	β , prepared at 180-200°	530.4	S 6.23 ₈₀₀
	c	fused	528.3	S 8.37 ₈₀₀
K ₂ Cu(SO ₄) ₂ ·2H ₂ O	c		675.5	S — 1.17 ₈₀₀
K ₂ Cu(SO ₄) ₂ ·6H ₂ O	c		960.4	
K ₂ Cu(CO ₃) ₂	c	II	424.	
	c	IV	426.1	
	c	V	426.6	
KCl·AgCl	c		134.5	
KBr·AgBr	c		117.5	
3KBr·AgBr· $\frac{1}{2}$ H ₂ O	c		338.6	
KI·AgI	c		92.0	
KI·AgI· $\frac{1}{2}$ H ₂ O	c		110.7	
2KI·AgI· $\frac{1}{2}$ H ₂ O	c		206.8	
3KI·AgI	c		250.7	
3KI·AgI· $\frac{1}{2}$ H ₂ O	c		283.8	
3KI·2AgI·H ₂ O	c		334.2	
KCN·AgCN	c		6.9	S — 8.3
	500		— 1.4	
2KCN·AgCN	1320		24.80	
	330		25.65	
	220		26.05	
KCN·AuCN	aq.		4.8	
K ₂ PtCl ₄	c		254.7	
	aq.		242.4	S — 12.15 ₈₀₀
K ₂ PtCl ₆	c		299.6	
	aq.		286.2	
K ₂ PtBr ₄	c		221.3	S — 10.58 ^{19.4} ₈₀₀
	aq.		210.7	

Potassium

Formula	State	Description	Q_f , kcal. mole ⁻¹	Q , kcal. mole ⁻¹
K ₂ PtBr ₆	c		248.2	
	aq.		236.0	<i>S</i> — 12.21 ²⁰ ₂₀₀₀
K ₂ PtI ₆	aq.		172.9	
K ₂ IrCl ₆	c		286.1	
	aq.		273.	<i>S</i> — 13.1 ^{15.5} ₅₄₀₀
K ₂ IrCl ₅	c		375.5	<i>S</i> — 7.9 ¹⁰ ₅₆₀₀
	aq.		367.6	
KReO ₄	c		298.37	<i>S</i> — 13.88 ₃₆₀₀
	∞	K ⁺ (∞) + ReO ₄ ⁻ (∞)	284.5	
	14200		284.48	
	7200		284.46	
	3600		284.49	
K ₂ PdCl ₄	c		261.6	<i>S</i> — 13.64 ^{19.5} ₈₀₀
	aq.		248.0	
K ₂ PdCl ₆	c		292.	
	aq.		277.	
K ₂ PdBr ₄	c		218.3	<i>S</i> — 12.3
	aq.		206.	
K ₃ RhCl ₆	aq.		386.3	
2KCN·Ni(CN) ₂	aq.		40.3	
K ₂ CO ₃ ·CoCO ₃	c		451.9	
K ₂ CO ₃ ·CoCO ₃ ·4H ₂ O	c		736.8	
KFe(SO ₄) ₂	600		495.14	
K ₂ Fe(SO ₄) ₂	440		527.29	
K ₃ Fe(SO ₄) ₂ ·4H ₂ O	c		837.	
K ₂ Fe(SO ₄) ₂ ·6H ₂ O	c		937.	<i>S</i> 10.3 ₂₀₀
K ₃ Fe(SO ₄) ₃	660		830.03	
K ₃ Fe(CN) ₆	c		48.5	
	aq.		34.1	
K ₄ Fe(CN) ₆	c		131.9	
	aq.		119.5	
K ₄ Fe(CN) ₆ ·3H ₂ O	c		340.3	
K ₃ FeCO(CN) ₅	c		143.1	<i>S</i> — 5.1 ₂₀₀₀
	aq.		138.0	
K ₃ FeCO(CN) ₅ ·3½H ₂ O	c		388.2	<i>S</i> — 10.9 ₂₅₀₀
KH ₂ Fe(CN) ₆	aq.		— 87.2	
KH ₃ Fe(CN) ₆	aq.		— 61.7	
K ₂ HFe(CN) ₆	aq.		— 26.1	
K ₂ H ₂ Fe(CN) ₆	aq.		— 1.4	
K ₃ HFe(CN) ₆	aq.		59.1	
KMnO ₄	c		192.9	<i>S</i> — 10.4 ₅₀₀
	400		182.5	
K ₂ Mn(SO ₄) ₂	c		594.9	<i>S</i> 6.34 ₆₀₀
K ₂ Mn(SO ₄) ₂ ·2H ₂ O	c		740.8	<i>S</i> — 2.87 ₈₀₀

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	Q , $kcal. mole^{-1}$
$K_2Mn(SO_4)_2 \cdot 4H_2O$	c	I II	881.1	$S - 6.38_{600}$
K_2CrO_4	c			$T - 2.45_{664} \rightarrow 11$
	c		333.4	$S - 5.25_{540}$
	2185		328.53	
	1945		328.49	
	1722		328.44	
	440		328.0	
	21.47		326.80	
$K_2Cr_2O_7$	c		488.5	$S - 16.69_{400}$
	1600		470.69	
	800		471.25	
	400		471.8	
	200		427.34	
	100		472.87	
$KCl \cdot CrO_3$	c		246.4	$S - 4.65_{400}$
$K_2Cr_2O_7 \cdot CrO_3$	c		599.	$S - 13.3_{180}$
$KCr(SO_4)_2$	c		500.	
	600		554.93	
$KCr(SO_4)_2 \cdot H_2O$	c		581.	
$KCr(SO_4)_2 \cdot 2H_2O$	c		659.	
$KCr(SO_4)_2 \cdot 6H_2O$	c		958.	
$KCr(SO_4)_2 \cdot 12H_2O$	c		1384.9	$S - 9.56_{800}$
KNH_4CrO_4	c		305.3	$S - 5.25_{385}$
	330		300.0	
K_2MoO_4	880		364.0	
$2KCl \cdot UO_2Cl_2 \cdot 2H_2O$	c		656.3	$S - 2.0^{19}_{2000}$
KVO_3	c		321.8	$S - 3.9$
	aq.		317.9	
KVO_4	c		308.2	$S - 4.0$
	aq.		304.2	
KVO_5	aq.		290.2	
$3KF \cdot AlF_3$	c		777.57	
	3800		773.77	
$3KF \cdot AlF_3 \cdot 3\frac{1}{2}H_2O$	c		1033.39	
$KCl \cdot AlCl_3$	c		283.8	$S - 60.82_{900}$
$3KCl \cdot AlCl_3$	c		496.9	$S - 47.49_{1330}$
$3KCl \cdot 2AlCl_3$	c		675.7	$S - 113.42_{2000}$
$KAl(SO_4)_2$	c		569.	
	600		617.53	
$KAl(SO_4)_2 \cdot H_2O$	c		723.	
$KAl(SO_4)_2 \cdot 2H_2O$	c		473.4	$S - 2.4$
$KAl(SO_4)_2 \cdot 3H_2O$	c		796.	
$KAl(SO_4)_2 \cdot 12H_2O$	c		1448.1	$S - 10.10_{800}$
$KCl \cdot AlCl_3 \cdot 6NH_3$	c		648.	
$K_2O \cdot Al_2O_3 \cdot 4SiO_2$	c	leucite	1379.6	

Potassium

Formula	State	Description	Q_f , $kcal. mole^{-1}$	$Q, kcal. mole^{-1}$	
$K_2O \cdot Al_2O_3 \cdot 4SiO_2$	gls.		1368.2		
$K_2O \cdot Al_2O_3 \cdot 6SiO_2$	c	adularia	1810.6		
$K_2O \cdot Al_2O_3 \cdot 6SiO_2$	c	microcline	1784.4		
$K_2O \cdot Al_2O_3 \cdot 6SiO_2$	gls.		1747.		
$KCl \cdot MgCl_2$	c	fresh melt	260.7		
$KCl \cdot MgCl_2 \cdot 6H_2O$	c		702.0		
$2KCl \cdot MgCl_2$	c	fresh melt	364.5		
$4KCl \cdot MgCl_2$	c	fresh melt	575.3		
$K_2Mg(SO_4)_2$	c	prepared below 150°	650.05	<i>S</i>	11.53 ₈₀₀
$K_2Mg(SO_4)_2$	c	fresh melt	654.71	<i>S</i>	6.92 ₈₀₀
$K_2Mg(SO_4)_2 \cdot 2H_2O$	c		797.70	<i>S</i>	0.68 ₈₀₀
$K_2Mg(SO_4)_2 \cdot 4H_2O$	c		945.4		
$K_2Mg(SO_4)_2 \cdot 5H_2O$	c		991.58	<i>S</i> —	8.09 ₈₀₀
$K_2Mg(SO_4)_2 \cdot 6H_2O$	c		1081.83	<i>S</i> —	10.02 ₈₀₀
$2KCl \cdot CaCl_2$	c	fresh melt	401.8		
$K_2SO_4 \cdot CaSO_4 \cdot H_2O$	c		757.5		
$K_2SO_4 \cdot 5CaSO_4 \cdot H_2O$	c		2131.1		
$KCaFeCO(CN)_5 \cdot 5H_2O$	c		— 933.		
$K_2SO_4 \cdot SrSO_4$	c		688.1		
$KLiICl$	c	fresh melt	176.6		
NaK	liq.		2.1		
NaK_2	liq.		5.3		
NaK_3	liq.		5.6		
Na_2K	liq.		0.4		
$KCl \cdot NaCl$	c	fresh melt	202.01		
$KNaICl$	c	fresh melt	176.59		
Na_2KPO_4	330		474.6		
$3KCNS \cdot NaCNS$	c		180.6		

Rubidium

Atomic number 37

Standard state Rb (c)

Atomic weight 85.44

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
Rb	g	4p ⁶ 5s (² S _{1/2})	— 18.9	<i>V</i> — 18.2 ⁴⁰⁰
	liq.			<i>F</i> — 0.53 ³⁹
	c		0.000	
Rb*	g	4p ⁶ 5s (² P _{1/2})	— 44.68	<i>E^z</i> — 35.781
	g	(² P _{3/2})	— 45.39	<i>E^z</i> — 36.486
Rb ⁺	g	4p ⁶ (¹ S ₀)	— 116.25	<i>I^z</i> — 95.90
	∞		61.04	
Rb ⁺⁺	g	4p ⁵ (² P _{3/2})	— 749.3	<i>I^z</i> — 631.56
Rb ₂ O	c		82.9	<i>S</i> 80.0 ₉₀₀₀
Rb ₂ O ₂	c		107.	
Rb ₂ O ₄	c		137.	
RbH	c		12.	
RbOH	c	II	101.3	<i>S</i> 14.4 ₂₀₀
	c	I		<i>T</i> 1.70 ²⁴⁵ → II
	∞	Rb ⁺ (∞) + OH ⁻ (∞)	115.7	
	200		115.7	
	3.18		112.9	
RbOH· $\frac{183}{1000}$ H ₂ O	c		149.8	<i>S</i> 7.78 ₁₁₀
RbOH·H ₂ O	c		180.2	<i>S</i> 3.87 ₁₁₀
RbOH·2H ₂ O	c		253.0	<i>S</i> — 0.56 ₁₁₀
RbF	g		79.8	<i>V</i> — 40.2 ¹³⁰⁰
	c		133.24	<i>S</i> 5.91 ₁₁₀
	∞	Rb ⁺ (∞) + F ⁻ (∞)	139.240	
	6400		139.218	
	3200		139.211	
	1600		139.202	
	800		139.189	
	400		139.173	
	200		139.157	
	100		139.150	
RbF· $\frac{1}{3}$ H ₂ O	c		158.08	<i>S</i> 3.86 ₁₁₀
RbF· $1\frac{1}{3}$ H ₂ O	c		242.27	<i>S</i> — 0.56 ₁₁₀
RbHF ₂	c		219.7	<i>S</i> — 5.17 ₁₁₀
	aq.		214.4	
RbCl	g		53.6	<i>V</i> — 37.7 ¹²⁰⁰
	c		105.08	<i>S</i> — 4.35 ₂₀₀
	∞	Rb ⁺ (∞) + Cl ⁻ (∞)	100.727	
	6400		100.704	
	3200		100.696	
	1600		100.691	
	800		100.688	
	400		100.698	
	200		100.733	

Rubidium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
RbCl	100		100.847	
RbBr	g		45.0	
	c		95.83	<i>S</i> — 5.86 ₁₁₀
	∞	Rb ⁺ (∞)+Br ⁻ (∞)	89.710	
	6400		89.690	
	3200		89.686	
	1600		89.684	
	800		89.690	
	400		89.720	
	200		89.800	
	100		89.970	
RbI	g		31.2	<i>V</i> — 36.7 ¹¹⁰⁰
	c		81.03	<i>S</i> — 6.5 ₂₀₀
	∞	Rb ⁺ (∞)+I ⁻ (∞)	74.410	
	6400		74.391	
	3200		74.388	
	1600		74.388	
	800		74.395	
	400		74.432	
	200		74.530	
	100		74.730	
Rb ₂ S	c		88.	<i>S</i> 24.6
	∞	2Rb ⁺ (∞)+ S ⁻⁻ (∞)	112.08	
Rb ₂ SO ₄	c		344.48	<i>S</i> — 6.43 ₂₀₀
	∞	2Rb ⁺ (∞)+ SO ₄ ⁻⁻ (∞)	337.880	
	6400		337.760	
	3200		337.743	
	1600		337.744	
	800		337.770	
	400		337.850	
	200		338.050	
RbHSO ₄	c		277.6	<i>S</i> — 3.58 ₂₀₀
	aq.		274.1	
RbI·4SO ₂	c		405.0	<i>D</i> — 10.1
RbNO ₃	c	II	119.24	<i>S</i> — 8.91 ₄₀₀
	c	I		<i>T</i> 1.05 ¹⁶⁴ →II
	∞	Rb ⁺ (∞)+ NO ₃ ⁻ (∞)	110.230	
	6400		110.201	
	3200		110.206	
	1600		110.220	
	800		110.257	
	400		110.339	

Rubidium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
RbNO ₃	200		110.495	
	100		110.750	
RbBr·3NH ₃	c		150.0	<i>D</i> — 7.1
RbI·6NH ₃	c		191.7	<i>D</i> — 7.5
Rb ₂ CO ₃	c		273.66	<i>S</i> 9.13 ₂₂₀
	∞	2Rb ⁺ (∞) + CO ₃ ⁻⁻ (∞)		
			282.58	
	2000		282.54	
	220		282.79	
	5.76		281.58	
Rb ₂ CO ₃ ·H ₂ O	c		348.11	<i>S</i> 3.05 ₂₂₀
Rb ₂ CO ₃ ·1½H ₂ O	c		385.38	<i>S</i> — .03 ₂₂₀
Rb ₂ CO ₃ ·3½H ₂ O	c		525.56	<i>S</i> — 3.48 ₂₂₀
RbHCO ₃	c		230.44	<i>S</i> — 4.60 ₂₂₀
	2000		225.84	
3Rb ₂ CO ₃ ·2RbHCO ₃ ·4½H ₂ O	c		1615.4	<i>S</i> — 7.7
RbCNS	c		56.	<i>S</i> — 14.
	aq.		42.1	
RbCNS·½SO ₂	c		96.8	<i>D</i> — 10.6
2RbI·PbI ₂	c		109.55	<i>S</i> 81.08 ₁₉₀₀
2RbI·PbI ₂ ·4H ₂ O	c		490.80	<i>S</i> — 26.69 ₂₀₀₀
2RbCl·CuCl ₂	c		269.0	<i>S</i> — 3.06 ₈₀₀
2RbCl·CuCl ₂ ·2H ₂ O	c		413.3	<i>S</i> — 10.65 ₈₀₀
2RbCl·ThCl ₄	c		565.2	<i>S</i> 28.1
2RbCl·ThCl ₄ ·9H ₂ O	c		1207.7	<i>S</i> 1.0
4RbCl·ThCl ₄	c		782.9	<i>S</i> 11.82
RbAl(SO ₄) ₂	c		567.	
RbAl(SO ₄) ₂ ·H ₂ O	c		646.	
RbAl(SO ₄) ₂ ·2H ₂ O	c		722.	
RbAl(SO ₄) ₂ ·3H ₂ O	c		796.	
RbAl(SO ₄) ₂ ·12H ₂ O	c		1450.	

Cesium				
Atomic number 55	Standard state Cs (c)		Atomic weight 132.91	
Formula	State	Description	Q_f , <i>kcal. mole</i> ⁻¹	Q , <i>kcal. mole</i> ⁻¹
Cs	g	5p ⁶ s (² S _{1/2})	- 18.8	
	liq.		- 0.5	F - 0.50 ²⁶
	c		0.000	
Cs*	g	5p ⁶ 6p (² P _{1/2})	- 50.62	E° - 31.82
	g		- 52.20	E° - 33.397
Cs ⁺	g	5p ⁶ (¹ S ₀)	- 109.65	I° - 89.40
	g		62.04	
	∞		- 649.8	I° - 538.7
Cs ⁺⁺	g	5p ⁵ (² P _{3/2})	- 82.1	S 83.2 ₃₄₀₀
Cs ₂ O	c		163.5	
Cs ₂ O ₄	c		12.	
CsH	c		100.2	S 16.56 ₁₁₀
CsOH	c	II		T 1.76 ²²³ →II
	c	I		
	∞	Cs ⁺ (∞) + OH ⁻ (∞)	116.7	
	200		116.7	
	2.16		113.36	
CsOH·H ₂ O	c		180.69	S 4.48 ₁₁₀
CsF	g		81.	V - 36. ¹²⁰⁰
	c		131.68	S 8.51 ₁₁₀
	∞	Cs ⁺ (∞) + F ⁻ (∞)	140.24	
	800		140.20	
	200		140.19	
	100		140.19	
CsF· $\frac{2}{3}$ H ₂ O	c		181.41	S 4.34 ₁₁₀
CsF·1 $\frac{1}{2}$ H ₂ O	c		241.65	S 1.10 ₁₁₀
CsHF ₂	c		219.1	S - 3.62 ₁₁₀
	aq.		215.4	
CsCl	g		55.4	
	c	I		T 1.34 ⁵² →II
	c	II	106.32	S - 4.54 ₂₀₀
	∞	Cs ⁺ (∞) + Cl ⁻ (∞)	101.727	
	6400		101.706	
	3200		101.702	
	1600		101.703	
	800		101.712	
	400		101.732	
	200		101.801	
	100		101.912	
	50		102.097	
	25		102.427	
	g		47.8	V - 36.4 ¹⁰⁰⁰
	c		97.65	S - 6.60 ₁₁₀
CsBr	∞	Cs ⁺ (∞) + Br ⁻ (∞)	90.710	
	6400		90.692	

Cesium

Formula	State	Description	Q_f , $kcal, mole^{-1}$	$Q, kcal. mole^{-1}$
CsBr	3200		90.690	
	1600		90.691	
	800		90.700	
	400		90.740	
	200		90.85	
	100		91.05	
CsI	g		37.5	
	c		83.90	S — 8.12 ₁₁₀
	∞	$Cs^+(\infty) + I^-(\infty)$	75.410	
	6400		75.393	
	3200		75.392	
	1600		75.393	
	800		75.403	
	400		75.455	
	200		75.57	
	100		75.78	
CsI ₃	c		91.9	D — 17.5
CsI ₄	c		92.3	D — 15.8
Cs ₂ S	c		87.	S — 27.3
	∞	$2Cs^+(\infty) + S^{--}(\infty)$	114.08	
Cs ₂ SO ₄	c		344.85	S — 4.70 ₂₀₀
	∞	$2Cs^+(\infty) + SO_4^{--}(\infty)$	339.880	
	6400		339.787	
	3200		339.780	
	1600		339.795	
	800		339.843	
	400		339.940	
	200		340.15	
	c		279.7	S — 3.55 ₂₀₀
	aq.		275.0	
CsI·4SO ₂	c		410.	D — 10.6
CsNO ₃	c	II	121.10	S — 9.74 ₄₀₀
	c	I		T — 0.83 ¹⁵⁴ → II
	∞	$Cs^+(\infty) + NO_3^-(\infty)$	111.230	
	6400		111.202	
	3200		111.210	
	1600		111.227	
	800		111.266	
	400		111.358	
	200		111.521	
	100		111.795	
	50		112.238	

Cesium

Formula	State	Description	Q_f , <i>kcal. mole⁻¹</i>	Q , <i>kcal. mole⁻¹</i>
CsNO ₃	25		112.980	
Cs ₂ CO ₃	c		272.76	<i>S</i> 12.06 ₂₂₀
	∞	2Cs ⁺ (∞) + CO ₃ ⁻⁻ (∞)	284.58	
	2000		284.54	
	220		284.82	
	7.59		284.58	
Cs ₂ CO ₃ ·3½H ₂ O	c		527.57	<i>S</i> — 3.45 ₂₂₀
CsHCO ₃	c		231.0	<i>S</i> — 4.17 ₂₂₀
	2000		226.8	
5Cs ₂ CO ₃ ·2CsHCO ₃ ·11H ₂ O	c		256.8	<i>S</i> — 8.
5Cs ₂ CO ₃ ·2CsHCO ₃ ·17½H ₂ O	c		3100.	<i>S</i> — 26.
CsCNS·½SO ₂	c			<i>D</i> — 10.1
2CsCl·CuCl ₂	c		272.7	<i>S</i> — 4.8 ₁₀₀₀
2CsCl·CuCl ₂ ·2H ₂ O	c		413.6	<i>S</i> — 9.0 ₁₀₀₀
2CsCl·ThCl ₄	c		562.5	<i>S</i> 32.9
2CsCl·ThCl ₄ ·8H ₂ O	c		1139.4	<i>S</i> 3.0
4CsCl·ThCl ₄	c		777.2	<i>S</i> 21.6
CsLiICl	c	melt	181.36	
CsNaICl	c	melt	181.91	
CsKICl	c	melt	187.49	
CsAl(SO ₄) ₂	c		569.	
CsAl(SO ₄) ₂ ·H ₂ O	c		647.	
CsAl(SO ₄) ₂ ·2H ₂ O	c		723.	
CsAl(SO ₄) ₂ ·3H ₂ O	c		797.	
CsAl(SO ₄) ₂ ·12H ₂ O	c		1451.	

Element 87

Atomic number 87

Standard state M (c)

Atomic weight (223?)

HELIUM

He (g). The values for the energy states of gaseous monatomic helium are from Hansen and Thorsen,¹ Hylleraas,¹ and Bacher and Goudsmit.¹

He (liq.). Vapor pressure data were reported by Dana and Onnes,^{1, 2} Keesom, Weber, and Ngaard,¹ Keesom, Weber, and Schmidt,¹ Onnes,^{1, 2} Onnes and Weber,^{1, 3} and Spangenberg.¹ We have utilized the data of Dana and Onnes.^{1, 2}

He (c). Simon and Steckel¹ reported values for the heat of fusion of helium at pressures from 1120 to 1860 kg per cm.² He (c) is not stable at 1 atmosphere. See also van Laar.¹¹

He₂ (g). The values for the energy states and the energy of dissociation of gaseous diatomic helium are from Weizel,^{1, 2, 3, 4, 5} Weizel and Pestel,¹ Weizel and Füchtbauer,¹ Imanishi,^{1, 2} Curtis,¹ Curtis and Harvey,¹ and Mulliken.⁶ See also Jevons.¹

NEON

Ne (g). The values for the energy states of gaseous monatomic neon are from Paschen,⁵ Hansen and Thorsen,¹ de Bruin,³ Russell, Compton, and Boyce,¹ Compton, Boyce, and Nickerson,¹ Bleakney,¹ and Bacher and Goudsmit.¹

Ne (liq.). Vapor pressure data for liquid neon were reported by Cath and Onnes,¹ Crommelin,⁵ Onnes and Crommelin,² Crommelin and Gibson,¹ Clusius,¹ Verschaffelt,² and Mathias, Crommelin, and Onnes.³

Ne (c). Verschaffelt² measured the vapor pressure of solid neon.

ARGON

A (g). The values for the energy states of gaseous monatomic argon are from Meissner,¹ Saunders,³ Compton, Boyce, and Russell,¹ Compton, Boyce, and Nickerson,¹ Bleakney,¹ and Bacher and Goudsmit.¹

A (liq.). Eucken^{2, 3} measured directly the heat of vaporization, obtaining $V = -1.501$ at -185.6° . This value is in agreement with the value -1.54 calculated from the vapor pressure data of Born,¹ Crommelin,^{1, 2, 3} and Mathias, Crommelin, and Onnes.^{3, 4}

A (c). Eucken and Hauch¹ measured the heat of fusion. See also Eucken.^{2, 3}

A · 5 H₂O (c). According to Villard⁸ and de Forcrand,⁶⁸ argon forms a well-defined pentahydrate. The latter's data on the dissociation pressure from 0 to 8° yield a value for the heat of the reaction of dissociating the solid hydrate into gaseous argon and liquid water.

KRYPTON

Kr (g). The values for the energy states of gaseous monatomic krypton are from Meggers, de Bruin, and Humphreys,¹ Bleakney,¹ Deb and Dutt,¹ Dejardin,¹ and Bacher and Goudsmit.¹

Kr (liq.). The vapor pressure data of Peters and Weil¹ yield $V = -2.31$ at the boiling point, -151.0° . Other vapor pressure data were reported by Ramsey,^{1,3} Ramsey and Travers,¹ and Patterson, Cripps, and Whytlaw-Gray.¹

Kr (c). We have estimated the heat of fusion of krypton.

Kr · 5 H₂O (c). According to Villard⁸ and de Forcrand⁶⁸ there is a well-defined pentahydrate of krypton. The latter computed the heat of dissociation into gaseous krypton and liquid water from his data on the dissociation pressure at temperatures from 0 to 12° .

XENON

Xe (g). The values for the energy states of gaseous monatomic xenon are from Meggers, de Bruin, and Humphreys,¹ Deb and Dutt,¹ and Bacher and Goudsmit.¹

Xe (liq.). The vapor pressure data of Peters and Weil¹ yield $V = -3.27$ at the boiling point, -108.6° . Other vapor pressure data were reported by Ramsey and Travers¹ and Patterson, Cripps, and Whytlaw-Gray.¹

Xe (c). We have estimated the heat of fusion.

Xe · 6 H₂O (c). According to de Forcrand,⁷⁰ there is a well defined hexahydrate. His data on the dissociation pressure at temperatures from 1.5 to 23.5° yield a value for the heat of dissociation of the solid hydrate into gaseous xenon and liquid water.

RADON

Rn (g). The values for the energy states of gaseous monatomic radon are from Rasmussen¹ and Bacher and Goudsmit.¹

Rn (liq.). We have estimated the heat of vaporization.

Rn (c). We have estimated the heat of fusion.

OXYGEN

O₂ (g). The standard state is taken to be the naturally existing mixture of oxygen molecules containing the atoms, O¹⁶, O¹⁷, and O¹⁸. The values for the energy states of gaseous diatomic oxygen are from Mulliken⁶ and Jevons.¹

O₂ (liq.), O₂ (c). We have selected Giaque and Johnston's¹ accurate calorimetric values for the heats of transition, fusion, and vaporization of oxygen. These and the earlier calorimetric data of Eucken,^{2,3} Alt,¹ Barschall,¹ and Keesom,¹ as well as the vapor pressure data of Cath,¹ Holst,⁴ Onnes and Braak,¹ Onnes and Crommelin,¹ and von Siemens,¹ are in substantial agreement.

O₂ (aq.). From the data of Winkler^{1,2,6,9,10} and Cassuto¹ on the solubility of oxygen in water at various temperatures we have calculated $S=3.85$. Washburn and Strachan¹ computed $S=3.0$.

O (g). The value for the energy of dissociation of the normal oxygen molecule into normal oxygen atoms is 5.09 ± 0.03 volt-electrons. This

value is from Herzberg,² Wigner and Witmer,¹ Birge,^{2, 3, 5} and Birge and Sponer.¹ See also Henri,¹ Mecke,⁵ Kondratjew,¹ Baxter,¹ Jenckel,¹ Eucken,¹ and Warburg.¹ Copeland¹ and Rodebush and Troxel¹ made direct calorimetric measurements of the energy of recombination of oxygen atoms on a palladium surface, but their values, though identical, are about 12 per cent higher than the accepted value and may indicate a systematic error. See also Reisenfeld and Schumacher,¹ Reisenfeld and Wassmuth,¹ and Kassel.^{1, 2}

The values for the energy states of gaseous monatomic oxygen are from Frerichs,^{1, 2} Paschen,⁸ Bowen,^{1, 2, 8} Kaplan,¹ Sommer,¹ McLennan and Crawford,¹ Hopfield,¹ Russell,⁵ Fowler,¹ Fowler and Hartree,¹ Laporte and Young,² Edlen and Ericson,¹ and Bacher and Goudsmit.¹

$O^-(g)$. The electron affinity of the oxygen atom may be evaluated by extrapolation of the square root of the ionization potentials of F, Ne, and Na, but adequate data for F are not available. The only other method which presents itself is by way of the reaction $MO(c) = M^{++}(g) + O^-(g)$. Using the values for the lattice energies as given by Sherman,² and taking the values for the heats of formation for $MO(c)$ and $M^{++}(g)$ from our tables, we have calculated the following values for the heat of formation of $O^-(g)$ from the data on the various metallic oxides: -224.9 , MgO; -226.8 , CaO; -224.6 , SrO; -222.6 , BaO; -226.2 , Li_2O ; -204 , NiO; -231.0 , ZnO; -187.4 , CdO; -260 , SnO_2 . We have selected as a mean, the value -225 , which gives for the electron affinity of the oxygen atom, $O(g) + 2\theta = O^-(g)$, $Q = 166$. Senftleben¹ gave -40 for the electron affinity, but his calculation via OH^- is very uncertain; Lande's¹ data lead to 265 , which is apparently in error.

$O_3(g)$. Berthelot^{38, 134} and Mulder and Van der Muelen^{1, 2} measured the heat of the reaction between $O_3(g)$ and $As_2O_3(aq.)$. Combining their data with those of Thomsen for the reaction between $O_2(g)$ and $As_2O_3(aq.)$, we have computed the following values for Q_f of $O_3(g)$: Berthelot, 32.5 ± 1.5 ; Mulder and Van der Meulen, 33.7 ± 2.0 . Recent determinations of this quantity have been made by direct catalytic decomposition. Van der Meulen, using a platinum catalyst, obtained 35.9 ; the data of Kailan and Jahn,³ and Jahn³ (cf. Woods¹), who passed ozone over soda lime, lead to 34.50 ± 0.2 . This latter value may be accepted with considerable confidence inasmuch as Kailan and Jahn³ have shown that the use of platinum as a catalyzer results in high values, probably due to oxidation of the catalyst. See also Rideal and Kunz,¹ and Born and Gerlach.¹

$O_3(liq.)$. Spangenberg¹ determined the heat of vaporization of liquid ozone.

$O_3(aq.)$. The heat of solution of ozone was computed from the data of Fischer and Tropsch¹ and Rothmund¹ on the solubility of ozone in water at various temperatures.

$O_4(g)$. The existence of O_4 was first postulated by Lewis³ in order to explain the anomalous magnetic properties of oxygen. and his expres-

sion for the equilibrium constant gives for $O_4(g)$, $Q_f = 0.13$. Wulf¹ found bands in the absorption spectra of oxygen which he assigned to the O_4 molecule. If, following Kondratjew,¹ it is assumed that the band at $47,500\text{ cm}^{-1}$ is associated with the reaction, $O_4(g) (\text{normal}) = O_3(g) (\text{normal}) + O(g) (^1D)$, then for $O_4(g)$, $Q_f = 1.2$.

HYDROGEN

$H_2(g)$. The standard state of hydrogen is taken to be the naturally existing mixture of diatomic hydrogen molecules containing atoms of protium (H^1) and deuterium (H^2), the molecules being in equilibrium at 18° with respect to the ortho and para rotational states. See Dennison,¹ Bonhoeffer and Harteck,¹ Giaque,¹ Elbe and Simon,¹ Davis and Johnston,¹ and Johnston and Long.¹ For H^1H^1 at 18° , 0.2508 of the molecules are in the para rotational states and 0.7492 in the ortho, which is very nearly the high temperature distribution of 1 to 3. The number of atoms of H^2 in natural hydrogen is about 1 in 5000.

The values for the energy states of gaseous diatomic hydrogen are from Richardson^{3, 4, 5} and Richardson and Das.^{1, 2} See also Sandeman,¹ Dieke and Hopfield,¹ Hori,³ Schaafsma and Dieke,¹ Richardson and Davidson,^{1, 2, 3, 4, 5} Finkelnburg and Mecke,^{1, 2} Mulliken,⁶ Jevons,¹ and Burrau.¹

$H_2(\text{liq.})$. The calorimetric determinations of the heat of vaporization by Simon and Lange,¹ Keesom,¹ Onnes and Keesom,¹ Mathias, Crommelin, and Onnes,¹ Dewar,³ and Eucken^{2, 3} are in substantial agreement, as are values calculated from vapor pressure data by Dewar,³ de Forcrand,^{61, 62} Cederberg,¹ Onnes and Keesom,¹ Van Laar,^{2, 5} Eucken, Karwat, and Fried,¹ Simon,^{5, 6} Eucken and Fried,² Crommelin and Onnes,² Keesom,¹ and Onnes and Martinez.¹

$H_2(c)$. For the heat of fusion we have taken Simon and Lange's¹ value, which is in agreement with the earlier values of Keesom and Onnes,¹ but not with that of Dewar.³ These data are presumably for the 1 to 3 mixture of para and ortho hydrogen.

$H_2(aq.)$. The heat of solution is computed from the solubility-temperature data of Turnofejen¹ and Winkler.⁹

$H(g)$. The International Critical Tables (see Bichowsky¹) value for the heat of formation of monatomic hydrogen was taken from Witmer¹ and Dieke and Hopfield,¹ who gave $D^\circ = 4.35$ volt-electrons. It has since been shown that the last line of Witmer's Lyman band is spurious, and the slightly higher value of 4.47 volt-electrons is obtained. The calorimetric data of Bichowsky and Copeland¹ yield $D^\circ = 4.47 \pm 0.15$ volt-electrons. Richardson and Davidson⁵ carefully reviewed all the data on the energy of dissociation of hydrogen and concluded that $D^\circ = 4.46 \pm 0.04$ volt-electrons.

See Bacher and Goudsmit¹ for a discussion of the energy states of gaseous monatomic hydrogen.

$\text{H}^- (\text{g})$. The electron affinity of the hydrogen atom can be determined in several ways. Extrapolation of the ionization potentials of Be^{++} , Li^+ , and He to H^- yields a value of 1.40 volt-electrons. The electron affinity can also be calculated from the lattice energy of the ionic LiH crystal. Assuming that the repulsive force varies as $1/r^5$ for both Li^+ and H^- , we have calculated for the lattice energy of LiH , the value 218.2. Hylleraas,⁴ using a similar method, obtained 217. Hylleraas⁴ also calculated this quantity by means of the new quantum mechanics, obtaining 218.6. This last calculation gives atomic distances in LiH in exact accord with the known density.

$\text{H}^+ (\text{aq.})$. It is conventional to take the heat of formation of aqueous hydrogen ion as zero at infinite dilution. This value, of course, has no relation to the actual heat of formation of $\text{H}^+ (\text{aq.})$, which quantity could be determined if the heat of solution of $\text{H}^+ (\text{g})$ were known. Though we have no accurate knowledge of the heat of solution of $\text{H}^+ (\text{g})$, its value can be estimated in several ways. The method of Latimer¹ requires a knowledge of the absolute potential of the hydrogen electrode and the entropy of $\text{H}^+ (\text{aq.})$; while that of Born requires a knowledge of the effective diameter, r , of the hydrogen ion and the dielectric constant, d , of water, which values are used in the formula $S = e^2/2r(1 - 1/d)$. The values obtained by these methods are, respectively, $S = 257$ and 225 ; and the absolute value of Q_f for $\text{H}^+(\text{aq.})$ becomes -108 and -140 , respectively. See also Fajans^{3, 4}. However, for practical reasons, we arbitrarily take, for $\text{H}^+ (\infty)$, $Q_f = 0$.

$\text{H}_2\text{O} (\text{liq.})$. At the time of the compilation of the thermochemical values for the International Critical Tables by Bichowsky,¹ the heat of formation of water had been measured by a large number of investigators: Despretz,² Dulong,² Grassi,¹ Abria,² Favre and Silbermann,¹ Andrews,^{4, 14} Thomsen,^{3, 15} von Than,^{1, 2, 3} Schuller and Wartha,¹ Berthelot,⁶⁹ Berthelot and Matignon,⁸ Mixer,^{2, 3} and Rümelin.¹ The first six of these investigations must be designated as pioneering studies, while those of von Than,^{1, 2, 3} Berthelot,⁶⁹ Berthelot and Matignon,⁸ and Rümelin¹ must be withdrawn from consideration for the following reasons: Five experiments were reported by von Than,^{1, 2, 3} who used an ice calorimeter and obtained an average deviation of about ± 0.05 per cent in the combustion experiments; but, unfortunately, his calibration data (energy equivalent of the calorimeter) are so few and so lacking in accuracy as to make the high precision of the combustion experiments practically valueless. Berthelot⁶⁹ reported the result of but one experiment. Berthelot and Matignon⁸ performed four experiments with an average deviation of about ± 0.9 per cent. The six results given by Rümelin¹ have an average deviation of about ± 0.5 per cent.

There remain to be considered the data of Thomsen^{3, 15} who burned oxygen in hydrogen in a flame at constant pressure in a calorimeter at room temperature; of Schuller and Wartha,¹ who burned oxygen in hydrogen in a flame at constant pressure in an ice calorimeter; and of

Mixer,^{2,3} who exploded oxygen and hydrogen at constant volume in a bomb calorimeter. The best of these three sets of data are those of Schuller and Wartha,¹ to which an accuracy of about ± 0.09 per cent may be attached. The data of these three investigations were reviewed by Lewis,² Roth,¹⁰ and Bichowsky,¹ who recommended the following values for the heat of formation of liquid water from gaseous hydrogen and oxygen (corrected to 18°): Lewis, 68.33; Roth, 68.39; Bichowsky, 68.38. Complete details of a recalculation of the calorimetric data of Thomsen,¹⁵ Schuller and Wartha,¹ and Mixer^{2,3} are given in a report by Rossini.¹

Recently, Rossini¹ determined with considerable accuracy (± 0.015 per cent) the heat of formation of water, using a flame calorimeter at constant pressure and burning both oxygen in hydrogen and hydrogen in oxygen. His method was a substitution one, in which the energy from a measured amount of electrical energy was substituted for the energy from a measured amount of chemical reaction, the calorimeter serving as the comparator of the two kinds of energy. Rossini¹ reported $285,775 \pm 40$ international joules per mole for the reaction at 25° and a constant pressure of 1 atmosphere. Corrected to 18° , and kilocalories, the value becomes 68.367 ± 0.010 . For the present tables, we have rounded off this value to 68.370.

H₂O (g). Values for the heat of vaporization of water were reported by Brix,¹ Regnault,^{5,7,9} Andrews,⁵ Favre and Silbermann,³ Berthelot,⁴⁴ Schall,¹ Dieterici,¹ Griffiths,² Louguine,¹⁰ Smith,^{3,4,5} Joly,⁵ Henning,^{1,2,4} Brown,¹ Richards and Mathews,^{1,2,3} Carlton-Sutton,¹ Mathews,³ Wrewsky,² Jakob,¹ Osborne, Stimson, and Fiock,¹ and Fiock and Ginnings.¹ The most accurate data are apparently those of the last two named investigations, whose data yield for 18° , $V = -10.571$. This value is in agreement with that obtained by Fiock¹ from a recalculation of the earlier data. See also Holborn, Scheel, and Henning.¹

H₂O (c). Values for the heat of fusion of ice were reported by Black,¹ Laplace and Lavoisier,¹ la Provostaye and Desain,¹ Desain,¹ Regnault,^{1,5} Hess,¹¹ Person,^{1,3,5} Leduc,¹ Bunsen,^{3,4} Smith,^{4,5} Behn,² Dieterici,² Zakrzewsky,² Bogojawlensky,¹ Noyes and Sammet,¹ Bridgman,⁵ Dickinson and Osborne,² and Dickinson, Harper, and Osborne.¹ The data of the last two named investigations are the most accurate and yield the value -1.437 at 0° .

OH (g). The normal state of the OH molecule is $^2\pi$. The next higher electronic energy state is $^2\Sigma$, and its energy has been shown by Birge¹ and Jack¹ to be 92.26 above that of the normal level. Bonhoeffer and Reichardt,¹ in an ingenious study of the intensity of lines in the absorption spectra of partially dissociated H₂O, determined the concentration of gaseous OH in equilibrium in the mixture at various temperatures and pressures. Their data yield for the reaction, $O_2(g) + 2H_2O(g) = 4OH(g)$, $Q = -134$; whence, for OH (g), $Q_f = -4.6$. By extrapolating the vibration levels of the $^2\Sigma$ state of OH, Bonhoeffer and Haber deduced $D^{\circ} = -70.6$ for the reaction, $OH(g) (^2\Sigma) = H(g) (nor-$

mal) + O (g) (2D_1); whence, for OH (g), $Q_f = 7.5$. Villars¹ gave, for OH (g) (normal) = O (g) (2D_1) + H (g) (normal), $D^{\circ} = -138$, yielding for OH (g), $Q_f = -17.3$; but his method is faulty. From spectroscopic data, Bates¹ found for the dissociation of normal OH into normal atoms of O and H, $D^{\circ} = -116.05$, whence, for OH (g), $Q_f = 5.93$.

OH⁻ (g). The heat of formation of OH⁻ (g) can be estimated by the method of lattice energies. Using the approximate formula for the lattice energy, with rough estimates of the crystal constants of NaOH, KOH, and RbOH from their densities and molecular weights, we have calculated from the data on these substances, for OH⁻ (g), $Q_f = -64$, -58 , and -56 , respectively. Lederle¹ calculated a value of -81 .

OH⁻ (∞). The heat of formation of OH⁻ (∞) is calculable from a knowledge of the heat of neutralization of a strong acid and a strong base at infinite dilution in water. That is to say, the reaction, $\text{NaOH} (\infty) + \text{HCl} (\infty) = \text{NaCl} (\infty) + \text{H}_2\text{O} (\text{liq.})$, is equivalent to the reaction $\text{OH}^- (\infty) + \text{H}^+ (\infty) = \text{H}_2\text{O} (\text{liq.})$. Rossini⁴ critically reviewed the data on heats of neutralization and heats of dilution, and, utilizing the Debye-Hückel theory for extrapolating to infinite dilution, calculated the following heats of neutralization at 18° and infinite dilution in water: KCl, 13.689; KNO₃, 13.713; NaCl, 13.699; NaNO₃, 13.720; LiCl, 13.703; LiNO₃, 13.734. The average value is 13.710, whence for OH⁻ (∞), $Q_f = 54.66$.

H₂O₂ (aq.). Thomsen¹⁵ measured the heat of reaction of (SnCl₂ + 4HCl) (500) with H₂O₂ (600) and with other oxidizing agents. His recomputed data yield, for H₂O₂ (600), $Q_f = 44.96$. Thomsen¹⁵ also measured the heat of reaction of KMnO₄ (aq.) with H₂O₂ (aq.) and with other reducing agents, but these data are less accurate than the former, and the reactions are not as clear cut. Berthelot³⁰ measured the heats of reaction of BaO₂ (c) + HCl (aq.) and of SnCl₄ (aq.) + BaCl₂ (aq.) + 2H₂O (liq.); these data yield, for H₂O₂ (aq.), $Q_f = 44.8$. Berthelot⁶² also measured the heat of decomposition of H₂O₂ with Ag₂O as a catalyst, —these data yielding $Q_f = 46.7$. Berthelot's⁶³ data on the reaction of H₂O₂ (aq.) + KI (aq.) must be disregarded because of the slowness of the reaction and because of side reactions. Favre and Silbermann² measured the decomposition of H₂O₂ with Pt as a catalyst, but their data are lacking in accuracy. Recently Matheson and Maass,¹ and Roth, Grau and Meichsner¹ independently measured the heat of decomposition of H₂O₂ (aq.) with MnO₂ as a catalyst. Their data yield the following values for the heat of formation of H₂O₂ in 0, 0.3, 1.8, 2.6, 6.3, 170, and 360 H₂O, respectively: 44.84, 44.91, 45.60, 45.63, 45.67, 45.68, and 45.75.

H₂O₂ (liq.). The foregoing data of Matheson and Maass¹ and of Roth, Grau, and Meichsner¹ yield, for the heat of solution of H₂O₂ (liq.) in water, $S_{200} = 0.88$; while the direct measurements of de Forcrand³² yield $S_{200} = 0.46$.

H₂O₂ (g). Maass and Hiebert¹ measured the heat of vaporization of H₂O₂ (liq.) to be 11.61. This direct determination supersedes the value

of 12.3 which was calculated by Lewis and Randall⁵ from the uncertain vapor pressure data of Wolfenstein¹ and Bruhl.¹

H_2O_2 (c). The data of Maass and Hatcher¹ and Maass and Waldbauer¹ yield $F = -2.51$ at -1.7° .

FLUORINE

F_2 (g). The energy states of the F_2 molecule are evaluated from the data of Gale and Monk¹ and Gale.¹ See Jevons.¹

F_2 (liq.). Cady and Hildebrand,¹ from their own vapor pressure data, computed $V = -1.60$ -¹⁸⁸. Henglein¹ estimated $V = -1.44$.

F_2 (c). Henglein¹ estimated $F = -0.34$.

F (g). The data of von Wartenberg, Sprenger, and Taylor,¹ who measured, spectroscopically, the convergence limit of the vibrational levels of F_2 (g), yield -62.6 for the energy of dissociation of normal F_2 (g) into normal fluorine atoms. Earlier estimates of this value were: Birge,¹ -70.0 ; Henglein,¹ -63.0 ; Villars,¹ -57 . See also Franck.²

The values for the energy states of gaseous monatomic fluorine are from Dingle,^{1, 2} de Bruin,² Bowen,² Turner,³ and Laporte and Young.¹ See also Bacher and Goudsmit.¹

F^- (g). Extrapolation of the ionization potentials of Ne and Na^+ gives 135 for the ionization energy of F^- (g), the negative of the electron affinity of F (g); but this method is known to give values that are too high. A more reliable value can be obtained by the method of lattice energies, utilizing the data on the alkali fluorides. We have computed values of the lattice energies of LiF , NaF , KF , RbF , and CsF which are identical with those given by Sherman¹ namely: 240.1, 215.0, 190.4, 181.8, and 172.8, respectively. Utilizing the remaining necessary data from our tables, we have computed, for F^- (g), the average value, $Q_f = 66.3$. This is equivalent to an electron affinity of 98, which is identical with the value given by Lederle.¹ Older values were given by Henglein,¹ Lande,¹ and Turner.³

HF (g). von Wartenberg and Fitzner¹ measured the heat of the reaction between gaseous fluorine and hydrogen to give the gaseous associated molecule $(\text{HF})_n$. According to present information, (see Simons and Hildebrand¹) the association of gaseous hydrogen fluoride is such that, at 18° and a pressure of 745 mm. Hg, the mean molecule is $(\text{HF})_{3.3}$. Utilizing the data of Simons and Hildebrand¹ on the reaction, $6 \text{ HF (g)} = (\text{HF})_6 \text{ (g)}$, von Wartenberg and Fitzner corrected their observed calorimetric data to give, for HF (g) (ideal), $Q_f = 63.0$. Later, von Wartenberg and Schutza¹ and Ruff and Laass¹ reported, for HF (g) (ideal), $Q_f = 64.5$ and 62.3 , respectively.

HF (aq.). The earliest determination of the heat of formation of fluorine compounds was made by Berthelot and Moissan,¹ who measured the heat of reaction between fluorine and an aqueous alkaline solution of potassium sulfite; but their data are of historical interest only. Guntz¹ found the heat of solution of hydrogen fluoride to be 11.8; von Wartenberg and Fitzner¹ gave, for HF (g) (ideal) $= \text{HF}$ (aq.), $Q = 11.56$. von

Wartenberg and Fitzner¹ also measured the heat of the reaction, $\frac{1}{2} \text{F}_2 (\text{g}) + \text{NaCl} (\text{c}) = \text{NaF} (\text{c}) + \frac{1}{2} \text{Cl}_2 (\text{g})$. Combining with this reaction the heat of formation of $\text{NaCl} (\text{c})$ and the heat of neutralization of $\text{HF} (\text{aq.})$, we have obtained, for $\text{HF} (\text{aq.})$, $Q_f = 77.0$. The heat of dilution of aqueous HF was measured by Guntz¹ and Peterson.⁶

HF (liq.). Guntz^{1, 5} measured the heat of solution of liquid HF in water. He gave $S = 4.6$, whence, for $\text{HF} (\text{liq.})$, $Q_f = 71.0$. Kolosovskii,¹ from vapor pressure data, computed $V = -6.3$, correcting an earlier calculation by Simons.¹ In a recent investigation, Fredenhagen¹ found $V = -6.05$ at 15° .

HF (c). Dahmlos and Jung¹ reported $F = -1.09$.

(HF)₆ (g). Simons and Hildebrand¹ studied the equilibrium, $6\text{HF} (\text{g}) = (\text{HF})_6 (\text{g})$, and concluded that $Q = 40.0$. They assumed that no other molecular species exist in gaseous hydrogen fluoride.

F⁻ (aq.). From the values of the heats of formation of $\text{LiF} (\infty)$, $\text{NaF} (\infty)$, $\text{KF} (\infty)$, and of $\text{Li}^+ (\infty)$, $\text{Na}^+ (\infty)$, and $\text{K}^+ (\infty)$, we have computed, for $\text{F}^- (\infty)$, $Q_f = 78.21, 78.13$, and 78.23 , respectively.

HF₂⁻ (aq.). From the values of the heats of formation of aqueous LiHF_2 , NaHF_2 , and KHF_2 at infinite dilution (assuming no dissociation of HF_2^-) we have obtained, for $\text{HF}_2^- (\infty)$, $Q_f = 153.67, 153.37$, and 153.40 , respectively.

F₂O (g). von Wartenberg and Klinkott¹ found for the reaction, $\text{F}_2\text{O} (\text{g}) + 2\text{KOH} (4.67) = 2\text{KF} (4.67) + 2\text{H}_2\text{O} (\text{liq.}) + \text{O}_2 (\text{g})$, $Q = 251.8 \pm 1.0$; whence, for $\text{F}_2\text{O} (\text{g})$, $Q_f = -6.7$. von Wartenberg and Klinkott¹ also measured the heats of the reactions, $\text{F}_2\text{O} (\text{g}) + 6\text{KI} (\text{aq.}) + 2\text{HF} (\text{aq.}) = (4\text{KF} + 3\text{KI}_3) (\text{aq.}) + \text{H}_2\text{O} (\text{liq.})$ and, at about the same concentration, $2\text{Cl}_2 (\text{g}) + 6\text{KI} (\text{aq.}) = (2\text{KI}_3 + 4\text{KCl}) (\text{aq.})$, finding, respectively, $Q = 176.4$ and 103 . Combination of these reactions leads to a value of -4.8 for the heat of formation of $\text{F}_2\text{O} (\text{g})$. von Wartenberg and Klinkott¹ also measured the heats of the reactions, $\text{F}_2\text{O} (\text{g}) + 4\text{HBr} (\text{aq.}) = 2\text{HF} (\text{aq.}) + 2\text{Br}_2 (\text{liq.}) + \text{H}_2\text{O} (\text{liq.})$ and $2\text{Cl}_2 (\text{g}) + 4\text{HBr} (\text{aq.}) = 4\text{HCl} (\text{aq.}) + 2\text{Br}_2 (\text{liq.})$, finding, respectively, $Q = 134.8$ and 49.1 . These data give, for $\text{F}_2\text{O} (\text{g})$, $Q_f = -5.7$. von Wartenberg and Klinkott¹ reported that Ruff measured the heat of the reaction, $2\text{H}_2 (\text{g}) + 2\text{NaOH} (\text{aq.}) + \text{F}_2\text{O} (\text{g}) = 2\text{NaF} (\text{aq.}) + 3\text{H}_2\text{O} (\text{liq.})$, and gave, from this source, $Q_f = -4.6$.

CHLORINE

Cl₂ (g). The standard state is taken as the equilibrium gas at 18° , containing the natural mixture of isotopes. The energy states of the diatomic chlorine molecule are evaluated from the data of Elliott,^{1, 2} and the discussion of Mulliken.⁶ See also Jevons.¹

Cl₂ (liq.). The heat of vaporization of liquid chlorine was measured by Estreicher and Schneer,³ Knietsch,¹ Pellaton,¹ Trautz and Gerwig,¹ Johnson and McIntosh,¹ Wohl,² and Eucken, Karwat, and Fried.¹ See also Harteck.¹

Cl₂ (c). The heat of fusion of chlorine was investigated by Estreicher

and Staniewski,¹ Estrieher and Schnee,¹ Eucken and Karwat,¹ and Harteck.² See also Rideal.¹ We have taken Eucken and Karwat's¹ value, $F = -1.62$ at -102° .

Cl (g). The heat of dissociation of Cl_2 (g) into atoms can be determined in several ways. Pier¹ and Wohl,^{2, 3} utilizing data on the instantaneous pressure developed in a closed bomb by explosion of $\text{H}_2 + \text{Cl}_2$, or $\text{H}_2\text{O} + \text{Cl}_2$, computed thermodynamically the heat of dissociation. Pier's¹ values were preliminary; Wohl^{2, 3} reported $D = -57.0$. The values from the explosion method are in accord with those deduced from the data of Henglein,¹ Trautz and Geissler,¹ von Wartenberg and Wiegel,¹ and von Wartenberg and Henglein,¹ all of whom measured the vapor density of gaseous chlorine at various high temperatures. These data on the equilibrium, Cl_2 (g) $= 2$ Cl (g), yield $D = -54.0$ and -59.5 . Trautz and Stackels¹ earlier value, -71.0 , from vapor density data, is evidently in error. The most accurate value for the energy of dissociation of the normal diatomic chlorine molecule into two normal chlorine atoms is obtained from the spectroscopic data of Kuhn,¹ who interpreted a band limit at 4758 Angstrom units as the dissociation of Cl_2 (g) (normal) into Cl (g) (2P_1) + Cl (g) (2P_2). Correcting to the normal state gives $D^\circ = -56.9$. Kuhn's¹ interpretation of the band limit was corroborated by Senftleben and Germer.¹

The values for the energy states of gaseous monatomic chlorine are from Kiess and de Bruin,¹ Muraka,^{1, 2} Bowen,⁴ Paschen,⁷ and Bowen and Millikan.¹ See also Bacher and Goudsmit.¹

Cl⁻ (g). Plotting the square root of the ionization potentials of A, K⁺, and Ca⁺⁺ against the atomic number, and extrapolating to Cl⁻, yields -65 for the energy of ionization of Cl⁻ (g). This is equivalent to the negative of the electron affinity of Cl (g). The heat of the reaction, Cl (g) $+ \theta = \text{Cl}^-$ (g), can also be calculated by way of the lattice energies of LiCl, NaCl, KCl, RbCl, and CsCl. Using our own values for the auxiliary data, we have computed from these substances the following values for Cl⁻ (g): $Q_f = 62.1, 63.2, 61.2$, and 63.7 , respectively. Similar calculations, varying but slightly from the foregoing in the values obtained, were made by Lennard-Jones¹ and Sherman.² Lederle,¹ from data on the absorption spectra of gaseous KCl, PbCl, and CsCl, calculated the electron affinity of Cl (g), and his values yield, respectively, for Cl⁻ (g), $Q_f = 60.4, 61.6$, and 60.2 .

Cl⁻ (∞). Since we have adopted the convention of making $Q_f = 0$ for H^+ (∞), the value for the heat of formation of Cl⁻ (∞) is identical with that for HCl (∞).

Cl₃ (g). The existence of this substance is still hypothetical and depends mostly on an interpretation of some rate of reaction experiments by Bodenstein and Plaut,¹ who assumed the reaction, 3Cl_2 (g) $= 2 \text{Cl}_3$ (g), and gave $Q = -51$.

Cl₂ (aq.) (ideal). Chlorine gas dissolved in water is in part hydrolyzed to form HCl and HClO. In addition, aqueous chlorine solutions decom-

pose slowly, evolving gaseous HCl and O₂. One can, however, consider that this last reaction is negligible in the observed calorimetric experiment of dissolving chlorine gas in water, and make proper correction for the amount of the reaction, $\text{Cl}_2 (\text{aq.}) + \text{H}_2\text{O} (\text{liq.}) = (\text{HCl} + \text{HClO}) (\text{aq.})$, which has occurred at the given temperature and concentration. Jakowkin¹ gave the equilibrium constant for this latter reaction, whence one can compute the amount of Cl₂ hydrolyzed and thence the correction which must be applied to the observed heat of solution in order to obtain the heat of the pure reaction without hydrolysis: $\text{Cl}_2 (\text{g}) = \text{Cl}_2 (\text{aq.})$ (ideal). Thomsen¹⁵ found $S_{1000} = 4.87$; Baker,² $S_7 = 4.97$; Berthelot,^{26, 67, 151} $S_7 = 7.4$. According to Jakowkin's¹ data on the hydrolysis constant for 18°, the chlorine in Thomsen's solution was 40 per cent hydrolyzed. Making correction for this amount of hydrolysis, we have calculated, for Cl₂ (aq.) (ideal), $Q_f = 7.0$. Utilizing, instead of the calorimetrically observed heat of solution, a value obtained from the temperature coefficient of solubility for Cl₂ in water, Jakowkin¹ calculated, for Cl₂ (aq.) (ideal), $Q_f = 7.1$. On recalculating his data, we have obtained 7.0. Roth¹² reviewed all the foregoing data and recommended the value 6.9.

Cl₂ (CCl₄). Noyes and Tulley¹ measured the heat of solution of chlorine in carbon tetrachloride at 0°.

ClO₂ (g). From explosion experiments, Booth and Bowen¹ found for ClO₂ (g), $Q_f = -23.5$. Mayer⁴ interpreted a predissociation band in the spectra of chlorine dioxide as due to the reaction $\text{ClO}_2 (\text{g}) = \text{Cl} (\text{g}) + \text{O}_2 (\text{g})$, and gave $Q = 3.6$; whence, for ClO₂ (g), $Q_f = -25.15$. This is a verification of the values of the heats of formation of both Cl (g) and ClO₂ (g).

ClO₂ (aq.). Booth and Bowen¹ reported $S = 6.60$.

ClO₂ (liq.). King and Partington¹ reported the heat of vaporization.

HClO₂ (aq.). The heat of solution of ClO₂ (g) in water is supposed to correspond to the reaction, $2 \text{ClO}_2 (\text{g}) + \text{H}_2\text{O} (\text{liq.}) = (\text{HClO}_3 + \text{HClO}_2) (\text{aq.})$. Anticipating the value of Q_f for HClO₃ (aq.), we have obtained, for HClO₂ (aq.), $Q_f = 13.8$.

ClO₂⁻ (aq.). Assuming that aqueous HClO₂ is completely ionized, one finds, for ClO₂⁻ (aq.), $Q_f = 13.8$.

ClO (g). Finkelnburg and Schumacker,¹ from spectral data, gave for the reaction, $\text{ClO}_2 (\text{g}) = \text{ClO} (\text{g}) + \text{O} (\text{g})$ (¹D), $Q = -111$.

Cl₂ · 7H₂O (c). Even though a hydrate of chlorine has been known for over a century, there is still some uncertainty as to its composition. Roozeboom³ believed the compound to be the octahydrate; de Forcrand,³⁸ the heptahydrate. de Forcrand³⁸ measured the heat of solution of a weighed amount of the hydrate in water, and, correcting for the variation of the composition of the compound from the supposed heptahydrate, obtained $S^3 = -15.87$, -15.27 , and -15.76 . At the same temperature and concentration, de Forcrand found, for Cl₂ (g), $S^3 = 2.94$; whence, for Cl₂ (g) + 7H₂O (liq.) = Cl₂ · 7H₂O (c), $Q^3 = 18.6$. In somewhat rougher experiments, LeChatelier^{3, 5} found for this latter reaction $Q = 17.0$. From

the equilibrium data of Isambert,⁴ LeChatelier,⁵ and Roozeboom,^{2, 4} de Forcrand³⁸ computed, for this reaction, $Q = 18.8$, 17.8 , and 17.8 , respectively. See also Tammann and Krige.¹ We have selected the value 18.0 , giving more weight to the values from the equilibrium data.

HCl (g). Calorimetric determinations of the heat of formation of gaseous hydrogen chloride were made by Abria,¹ Favre and Silbermann,¹ Berthelot,¹⁸¹ Thomsen,¹⁵ Roth and Richter,¹ von Wartenberg and Hanisch,¹ and Rossini.¹⁰ The values of Abria¹ and Favre and Silbermann,¹ 24.0 and 23.8 respectively, are now only of historical interest. The only information that we have been able to obtain concerning Berthelot's¹⁸¹ work on this problem is that he quoted Thomsen's¹⁵ value and wrote "J'ai obtenu le meme chiffre." Thomsen¹⁵ burned chlorine in hydrogen at constant pressure in a flame calorimeter. The detailed data of his four calorimetric experiments have been recomputed and yield, for HCl (g), $Q_f = 21.99 \pm 0.05$. Thomsen determined the amount of reaction in each experiment by absorbing the HCl and titrating with aqueous barium hydroxide.

von Wartenberg and Hanisch^{1, 2} performed similar experiments and reported, for HCl (g), $Q = 21.90 \pm 0.01$ at 24° . The amount of reaction in each experiment was computed from the loss in weight of the chlorine bottle. Roth and Richter¹ reported the results of three series of calorimetric experiments on the combination of hydrogen and chlorine by explosion at constant volume at 21° : Series I, 21.82 ± 0.06 , amount of reaction determined by titrating the hydrogen chloride formed; Series II, 22.02 ± 0.02 , chlorine in excess, amount of reaction determined from volume, pressure, and temperature of the hydrogen used in the reaction; Series III, 21.87 ± 0.03 , hydrogen chloride titrated. Roth and Richter¹ concluded that the third series was the most accurate and best represented the results of their work.

Rossini¹⁰ burned chlorine in hydrogen at constant pressure in a flame calorimeter, using the apparatus with which he made the accurate measurements on the heat of formation of water. He reported, for HCl (g), $Q_f^{25} = 22.063 \pm 0.012$; whence, at 18° , $Q_f = 22.060 \pm 0.012$. The amount of reaction in each experiment was determined by absorbing the HCl formed in a soda-asbestos mixture. In the same paper, Rossini¹⁰ made a detailed calculation of the heat of formation of gaseous HCl utilizing the thermodynamic relation $\Delta H = \Delta F + T\Delta S$. He obtained the value of ΔS , the entropy of formation, from the recently obtained accurate values of the entropies of H_2 , Cl_2 , and HCl from spectroscopic data by Giauque and coworkers; and the value of ΔF , the free energy of formation, from the electromotive force of cells giving the reactions, $\frac{1}{2}H_2(g) + AgCl(c) = Ag(c) + HCl(aq.)$ and $Ag(c) + \frac{1}{2}Cl_2(g) = AgCl(c)$, and the vapor pressure of HCl over aqueous HCl. In this manner Rossini¹⁰ computed, for HCl (g), $Q_f^{25} = 22.026 \pm 0.033$, which value is in accord, within its limits of uncertainty, with his directly measured calorimetric value. See also the discussion under HCl (aq.).

HCl (liq.). The heat of vaporization of HCl was measured by Elliott and McIntosh,¹ Steele, McIntosh, and Archibald,¹ Estreicher and Schneer,¹ and Giauque and Wiebe.¹ The value from Giauque and Wiebe¹ is accepted as being the most accurate. Tsurita¹ calculated $V = -2.38$. The vapor pressure of liquid HCl was measured by Faraday,¹ Ansdell,¹ McIntosh and Steele,¹ Briner,⁴ Drozdowski and Pietrzak,¹ Cardoso and Germann,¹ and Henning and Stock.¹

HCl (c, I). Giauque and Wiebe¹ and Eucken and Karwat¹ found, by direct measurement, $F = -0.504$ and -0.476 , respectively. The data of Eucken and Donath,¹ Eucken and Karwat,¹ and Giauque and Wiebe,¹ on the vapor pressure of solid and liquid HCl in the neighborhood of the triple point, yield $F = -0.498$.

HCl (c, II). Giauque and Wiebe¹ and Eucken and Karwat¹ found, respectively, $T_{\rightarrow I} = -0.284$ and -0.293 .

HCl⁺ (g). Foote and Mohler¹ gave for the energy of ionization of HCl (g) to form HCl⁺ (g) the value 14.0 volt-electrons; Barton¹ reported 13.8 volt-electrons. Other values were reported by Kemble,¹ Knipping,^{1,2} Franck,¹ Mackay,^{1,2} and Barker and Duffendack.¹

HCl (aq.). The data on the heat of dilution of aqueous HCl in the dilute region (Richards and Rowe,¹ Richards, Mair, and Hall,¹ Muller,¹ von Steinwehr,¹ and Wrewskii and Savaritzkii¹) were reviewed by Rossini,⁵ who gave values from ∞ to 25 H₂O. The data of Wrewskii and Savaritzkii,¹ Thomsen,¹⁵ and Berthelot,^{17,18} have been utilized to obtain values from 25 to 1 H₂O. Other data were given by Ellis,¹ Harned and Brumbaugh,¹ Tucker,¹ Richards, Rowe, and Burgess,¹ and Payn and Perman.¹

The heat of solution of gaseous HCl in water was measured by Thomsen,¹⁵ Berthelot and Louguinine,¹ and Wrewskii and Savaritzkii.¹ Their data yield for S_{200} : 17.20, 17.5, and 17.38, respectively. Combination of the last value with the heat of dilution from 200 to ∞ H₂O, and with the heat of formation of the gas, yields, for HCl (∞), $Q_f = 39.66$ (See Rossini¹⁰). Older data on the heat of solution of HCl were obtained by Favre and Silbermann,^{1,3} Favre,⁶ and Abria.² See also Wilke and Kieninger¹ and Wrewskii and Faerman.¹

The heat of formation of aqueous HCl can also be computed (see Rossini¹⁰) from the temperature coefficient of the electromotive force of certain cells and the heats of formation of silver chloride and mercurous chloride. Lewis and Randall,² Ellis,¹ and Harned and Brumbaugh¹ measured at a series of temperatures the electromotive force of cells in which the reaction was $\frac{1}{2} \text{H}_2 (\text{g}) + \text{HgCl} (\text{c}) = \text{Hg} (\text{liq.}) + \text{HCl} (\text{aq., } m)$, and computed the heat of the reaction. Addition to this quantity of the heat of formation of HgCl (c), and the partial molal heat of dilution of HCl from the molality m to infinite dilution, yields values for the reaction, $\frac{1}{2} \text{H}_2 (\text{g}) + \frac{1}{2} \text{Cl}_2 (\text{g}) = \text{HCl} (\infty)$. From the foregoing data, we have obtained the average value, for HCl (∞), $Q_f = 39.71$. In a similar manner Noyes and Ellis,¹ Harned and Brumbaugh,¹ and Butler and Rob-

ertson¹ obtained values for the heat of the reaction $\frac{1}{2} \text{H}_2 (\text{g}) + \text{AgCl} (\text{c}) = \text{Ag} (\text{c}) + \text{HCl aq., m})$. And from their data we have computed, for $\text{HCl} (\infty)$, the average value $Q_f = 39.63$. See Rossini.¹⁰

HCl (C₂H₅OH). Berthelot¹⁵² measured the heat of solution of gaseous HCl in ethyl alcohol.

HCl (CCl₄). Noyes and Tulley¹ measured the heat of solution of gaseous HCl in carbon tetrachloride.

HCl · 2 H₂O (c). Berthelot⁴⁷ measured the heats of solution of the solid and of the liquid in water. The difference in the observed heats of solution, for the same temperatures and concentration, gives the heat of the reaction, $\text{HCl} \cdot 2 \text{H}_2\text{O} (\text{c}) = \text{HCl} (2) + 2 \text{H}_2\text{O} (\text{liq.})$, $Q = -2.5$. Vapor pressure data on the system HCl–H₂O were reported by Roozeboom.^{3, 5}

HClO (aq.). Thomsen¹⁵ measured the heats of the reactions:

- (1), $\text{Cl}_2 (\text{g}) + 2 \text{NaOH} (400) = (\text{NaCl} + \text{NaClO}) (800) + \text{H}_2\text{O} (\text{liq.})$;
- (2), $\text{NaOH} (400) + \text{HClO} (400) = \text{NaClO} (800) + \text{H}_2\text{O} (\text{liq.})$;
- (3), $\text{NaOH} (400) + \text{HCl} (400) = \text{NaCl} (800) + \text{H}_2\text{O} (\text{liq.})$;
- (4), $\text{NaCl} (400) + \text{NaClO} (400) = (\text{NaCl} + \text{NaClO}) (800)$;
- (5), $\text{NaCl} (400) = \text{NaCl} (800)$; and
- (6), $\text{NaClO} (400) = \text{NaClO} (800)$.

Subtraction of (2) + (3) + (4) from (1) + (5) + (6) yields $\text{Cl}_2 (\text{g}) + \text{H}_2\text{O} (\text{liq.}) = \text{HCl} (400) + \text{HClO} (400)$. Our recalculation of Thomsen's data on the above reactions yields, for $\text{HClO} (400)$, $Q_f = 29.76$. Thomsen also measured the heat of the reaction, $\text{HClO} (400) + (2 \text{HCl} + 2 \text{KI}) (400) = (2 \text{KCl} + \text{HCl}) (800) + \text{H}_2\text{O} (\text{liq.}) + \text{I}_2 (\text{c})$. From his data on this reaction, we have computed, for $\text{HClO} (400)$, $Q_f = 29.79$. Recently, Neumann and Muller² measured the heats of the reactions, $\text{Cl}_2 (\text{g}) + 2 \text{MOH} (\text{aq.}) = (\text{MCl} + \text{MClO}) (\text{aq.}) + \text{H}_2\text{O} (\text{liq.})$ and $\text{MOH} (\text{aq.}) + \text{HClO} (\text{aq.}) = \text{MClO} (\text{aq.}) + \text{H}_2\text{O} (\text{liq.})$, where M was Li, Na, K, $\frac{1}{2} \text{Ca}$, $\frac{1}{2} \text{Sr}$, and $\frac{1}{2} \text{Ba}$, respectively. With these data one can compute the heat of the reaction $\text{Cl}_2 (\text{g}) + \text{MOH} (\text{aq.}) = \text{HClO} (\text{aq.}) + \text{MCl} (\text{aq.})$. Utilized in this manner, the foregoing data of Neumann and Muller yield six values for the heat of formation of $\text{HClO} (\text{aq.})$, the average being 30.4. In view of the fact that Neumann and Muller did not give their experimental measurements of the heat of neutralization of $\text{MOH} (\text{aq.}) + \text{HCl} (\text{aq.})$, and reported no values for the pertinent heats of mixing and dilution, we have selected the value from Thomsen's data. The heat of dilution of aqueous HClO was measured by Neumann and Muller.²

Cl₂O (g). Thomsen¹⁵ and Neumann and Muller² found for the heat of solution in water the values 9.44₈₀₀ and 8.74₂₀₇₀, respectively. Because we have selected the value of $\text{HClO} (\text{aq.})$ from Thomsen's data, we have also, to be consistent, taken his value for the heat of solution of $\text{Cl}_2\text{O} (\text{g})$ in water to form $\text{HClO} (\text{aq.})$. Recently, Gunther and Wekua¹ measured the heat of explosion of Cl_2O , their data yielding, for $\text{Cl}_2\text{O} (\text{g})$, $Q_f = -25.1$. Our selected value is -18.2 . The discrepancy may lie in a systematic error of the nature of the formation of ozone in the experiments of Gunther and Wekua.¹

Cl_2O (aq.). As Goldschmidt¹ pointed out, solutions of aqueous HClO more concentrated than about HClO (50) contain appreciable amounts of free unhydrated Cl_2O , in the equilibrium, 2HClO (aq.) $= \text{H}_2\text{O}$ (aq.) + Cl_2O (aq.). The data of Roth¹² and Goldschmidt¹ on the equilibrium constant at various temperatures yield -8.0 for the heat of the foregoing reaction.

HClO_3 (aq.). Thomsen¹⁵ measured the heat of the reaction, HClO_3 (1200) + $3\text{H}_2\text{SO}_3$ (400) $= (3\text{H}_2\text{SO}_4 + \text{HCl})$ (2400), obtaining as the average from three experiments, $Q = 206.3$. From these data, we have calculated, for HClO_3 (aq.), $Q_f = 24.6$. Berthelot⁷⁹ measured the heats of the reactions, $\text{Ba}(\text{ClO}_3)_2$ (200) + $6\text{H}_2\text{SO}_3$ (aq., satd.) $= \text{BaSO}_4$ (c) + $(5\text{H}_2\text{SO}_4 + 2\text{HCl})$ (aq.), and $\text{Ba}(\text{ClO}_3)_2$ (200) + H_2SO_4 (400) + 2HClO_3 (300) $= \text{BaSO}_4$ (c). Thomsen¹⁵ also measured the heat of this last reaction. From these data, we have computed, for HClO_3 (aq.), $Q_f = 20.8$. This latter value we have taken as the best for aqueous HClO_3 because the reactions involved are clear cut and rapid, as contrasted with the reaction between chloric and sulfurous acids.

HClO_4 (aq.). Berthelot⁷⁹ measured the heat of neutralization of aqueous HClO_4 with KOH (660), his data yielding $N = 14.25_{1320}$. Taking the heat of formation of KClO_4 (aq.) as known, we have computed, for HClO_4 (660), $Q_f = 39.6$. Berthelot^{79, 80} measured the heat of dilution of aqueous HClO_4 .

HClO_4 (liq.). Berthelot^{79, 80} measured the heat of solution.

$\text{HClO}_4 \cdot \text{H}_2\text{O}$ (c). Berthelot^{79, 80} measured the heat of solution.

ClO^- (aq.). The data on the heats of formation of aqueous LiClO , NaClO , and KClO , and of aqueous Li^+ , Na^+ , and K^+ yield, for ClO^- (aq.), $Q_f = 25.77$, 25.92 , and 25.93 , respectively.

ClO_3^- (∞). From the data on the heats of formation of NaClO_3 (∞) and Na^+ (∞), we have obtained, for ClO_3^- (∞), $Q_f = 20.75$.

ClO_4^- (∞). From the data on the heats of formation of NaClO_4 (∞), Na^+ (∞), KClO_4 (∞), and K^+ (∞), we have obtained, for ClO_4^- (∞), $Q_f = 39.35$ and 39.60 , respectively.

ClF (g). Fredenhagen and Krefft¹ observed that heat is evolved when Cl_2 and F_2 are mixed. Ruff and Laass¹ measured the heats of the reactions, ClF (g) + H_2 (g) $= \text{HCl}$ (g) + HF (g) and $1/2\text{F}_2$ (g) + $1/2\text{H}_2$ (g) $= \text{HF}$ (g); and their data yield, for ClF (g), $Q_f = 25.7$.

ClF (liq.). Ruff and Laass¹ computed, from vapor pressure data, $V = -2.27$ at -101° .

BROMINE

Br_2 (liq.). Standard state.

Br_2 (g). The heat of vaporization of liquid bromine was measured directly by Andrews,^{5, 10} Berthelot and Ogier,⁸ Le Chatelier,⁴ Regnault,⁷ and Thomsen.¹⁵ Vapor pressure data were reported by Scheffer and Voogd,¹ Bouzat and Letuan,¹ Cuthbertson and Cuthbertson,¹ Isnardi,¹ Ramsey and Young,¹ and Roozeboom.^{3, 5} All the foregoing data agree

with the equation given by Lewis and Randall⁵: $V = -10.45 + 0.0096(t + 273.1)$.

Br₂ (c). Regnault² measured directly $F = -2.53$. This value is in accord with the heat of sublimation computed from the vapor pressure data on solid bromine of Braune,¹ Isnardi,¹ Ramsay and Young,¹ Cuthbertson and Cuthbertson,¹ Henglein,² and Henglein, Rosenberg, and Muchlinski.¹ See also Rideal.¹

Br (g). Perman and Atkinson^{1, 2} and Bodenstein and Cramer¹ measured the vapor density of bromine gas at various elevated temperatures, and computed values of the equilibrium constant for the reaction, $\text{Br}_2(\text{g}) = 2\text{Br}(\text{g})$. Lewis and Randall⁵ reviewed the work of Perman and Atkinson^{1, 2} and deduced for this reaction: $Q = -41.60 - 0.0026(t + 273.1)$. The data of Bodenstein and Cramer¹ yield $Q = -46.10 - 0.0026(t + 273.1)$. DeVries and Rodebush¹ gave $Q = -41.2$. None of these values compare in accuracy with that obtained from spectroscopic analysis. Kuhn¹ reported for the above reaction $D^\circ = -45.2$. Kuhn's interpretation of the spectroscopic data has been corroborated by Senftleben and Germer.¹ In a similar manner, Brown³ recently deduced the accurate value $D^\circ = -45.24 \pm 0.07$.

The values for the energy states of gaseous monatomic bromine are from Kiess and de Bruin,² Turner,¹ and Deb.¹ See also Bacher and Goudsmit.¹

Br⁻ (g). The electron affinity of Br (g) is calculable by the method of lattice energies. Selecting the crystal RbBr, because Rb⁺ and Br⁻ have exactly the same nuclear structure, and taking the exponent of the repulsive term to be 10, we have computed, for the reaction, $\text{RbBr}(\text{c}) = \text{Rb}^+(\text{g}) + \text{Br}^-(\text{g})$, $D^\circ = -151.2$; whence the electron affinity of Br (g) becomes 87.9. Using the lattice energies of the alkali bromides as calculated by Sherman,¹ we have computed the values 89.6, 85.6, 84.6, 83.6, and 89.6, respectively. Butkow,¹ from the spectra of gaseous TlBr, deduced the value 86.5. From data on the absorption spectra of the alkali halides, Lederle¹ obtained the value 82. See also Lennard-Jones.²

Br₂ (aq.). Bromine, like chlorine, is hydrolyzed in water. From the heat of the hydrolysis reaction, and the value given by Bray and Connolly¹ for the hydrolysis constant at 25°, we have computed K^{18} (hydrolysis) =
$$\frac{(\text{H}^+)(\text{Br}) (\text{HBrO})}{(\text{Br}_2)} = 2.2 \times 10^{-9}$$
. The heat of solution of liquid

bromine in water was measured by Le Chatelier,⁴ Berthelot,⁹⁸ Pickering,⁸ and Thomsen.¹⁵ The last three investigators used 1 mole of Br₂ per 300, 5400, and 700 moles of water, and, correcting their data for the amount of bromine hydrolyzed, we have computed $S = 1.2$, -0.9 , and 1.24 . Berthelot⁹⁸ also measured the heat of solution of liquid bromine in dilute aqueous HCl, where the hydrolysis would be suppressed, finding $S = 1.1$.

Br₂ (CCl₄), Br₂ (CHCl₃), Br₂ (CS₂). Pickering⁸ measured the heat of solution of liquid bromine in carbon tetrachloride, chloroform, and carbon disulfide, respectively.

$\text{Br}_2 \cdot 10 \text{H}_2\text{O}$ (c). The vapor pressure data of Tammann and Krige¹ for the system, $\text{Br}_2 \cdot 10 \text{H}_2\text{O}$ (c) \rightarrow H_2O (c), yield $Q = -7.9^{10}$ for the reaction $\text{Br}_2 \cdot 10 \text{H}_2\text{O}$ (c) $=$ Br_2 (g) + $10 \text{H}_2\text{O}$ (c). This is in agreement with the data of Roozeboom.^{3, 4}

HBr (aq.). Thomsen¹⁵ measured the heat of the following reactions: $\frac{1}{2} \text{Cl}_2$ (g) + KBr (200) $=$ ($\text{KCl} + \frac{1}{2} \text{Br}_2$) (200); $\frac{1}{2} \text{Br}_2$ (liq.) $=$ $\frac{1}{2} \text{Br}_2$ (aq.). We have recomputed Thomsen's data on these reactions, obtaining for, $\frac{1}{2} \text{Cl}_2$ (g) + KBr (200) $=$ KCl (200) + $\frac{1}{2} \text{Br}_2$ (liq.), $Q = 10.94$, which is equivalent to the heat of formation of KCl (200) minus the heat of formation of KBr (200). By combining with this last equation the difference in the heats of neutralization of aqueous HCl and HBr with aqueous KOH , which is HCl (100) + KBr (200) $=$ HBr (100) + KCl (200), $Q = 0.024$, we have obtained, for $\frac{1}{2} \text{Cl}_2$ (g) + HBr (100) $=$ $\frac{1}{2} \text{Br}_2$ (liq.) HCl (100), $Q = 10.916$. From which we have computed, for HBr (100), $Q_f = 28.47$. Berthelot¹⁵¹ measured the heat of the reaction between $\frac{1}{2} \text{Br}_2$ (liq.) and KI (aq.), which for several reasons is preferable to the reaction studied by Thomsen¹⁵; but there is apparently some considerable error in Berthelot's data on this reaction. Berthelot⁴⁵ also measured the heats of the reactions, Br_2 (liq.) + SO_2 (aq.) and I_2 (c) + SO_2 (aq.), the difference between which gives the heat of the reaction $\frac{1}{2} \text{Br}_2$ (liq.) + HI (aq.) $=$ $\frac{1}{2} \text{I}_2$ (c) + HBr (aq.); but his data on these reactions are lacking in accuracy.

Thomsen measured the heats of the reactions, KCl (200) + AgNO_3 (400) $=$ AgCl (c) + KNO_3 (600) and KBr (200) + AgNO_3 (400) $=$ AgBr (c) + KNO_3 (600), the difference of which gives KCl (200) + AgBr (c) $=$ KBr (200) + AgCl (c). Combining with this equation, the difference in the heats of formation of AgCl (c) and AgBr (c), the difference in the heats of neutralization of HCl (100) and HBr (100) with KOH (100), and the heat of formation of HCl (100), we have obtained, for HBr (100), $Q_f = 28.63$. Utilizing, in a similar manner, the difference in the heats of reaction of KI (200) and of KBr (200) with AgNO_3 (200) as measured by Thomsen,¹⁵ the difference in the heats of formation of AgI (c) and AgBr (c), the difference in the heats of neutralization of HI (100) and HBr (100) with KOH (100), and the heat of formation of HI (100), we have computed, for HBr (100), $Q_f = 28.44$.

The heat of diluting aqueous HBr from 100 to $\infty \text{H}_2\text{O}$ has been computed from the following reactions whose heats are known: $\text{NaOH}(\infty) + \text{HBr}(\infty) = \text{NaBr}(\infty) + \text{H}_2\text{O}(\text{liq.})$; $\text{NaOH}(100) + \text{HBr}(100) = \text{NaBr}(201) + \text{H}_2\text{O}(\text{liq.})$; $\text{NaOH}(100) = \text{NaOH}(\infty)$; and $\text{NaBr}(201) = \text{NaBr}(\infty)$. The values for the heat of dilution in the more concentrated solutions to $1 \text{H}_2\text{O}$ are taken from the data of Berthelot,¹⁸ Roozeboom,⁸ and Thomsen.¹⁵

HBr (g). For the heat of solution of gaseous HBr in water, the data of Thomsen yield $S = 19.89_{400}$; Berthelot found $S = 20.0_{760}^{15}$.

HBr (liq.). The heat of vaporization of liquid HBr was measured by Elliott and McIntosh,¹ Estreicher and Schnee,¹ Eucken and Karwat,¹

and Giauque and Wiebe.² Vapor pressure data were reported by Maass and McIntosh,¹ Steele and Bagster,¹ Steel, McIntosh, and Archibald,¹ Eucken and Karwat,¹ and Giauque and Wiebe.² All these data are in accord, and we have selected the directly measured value of Giauque and Wiebe.²

HBr (c, I), HBr (c, II), HBr (c, III). The heat of fusion of HBr (c, I) and the heats of the two transitions of crystalline HBr were measured by Eucken and Karwat,¹ and by Giauque and Wiebe,² whose values we have selected. The vapor pressure of solid hydrogen bromide was measured by Henglein,³ Maass and McIntosh,¹ Steele, McIntosh, and Archibald,¹ and Drozdowski and Pietrzak.¹

HBr · H₂O (c). Roozeboom⁶ reported -3.0 for the heat of fusion.

HBr · 2 H₂O (c). Berthelot¹⁸ reported 16.9 for the heat of the reaction $\text{HBr (g)} + 2 \text{H}_2\text{O (liq.)} = \text{HBr} \cdot 2 \text{H}_2\text{O (c)}$, but no details of the experiments were reported. The vapor pressure data of Roozeboom⁶ are in accord with Berthelot's value.

Br₃⁻ (aq.). Berthelot^{105B, 151} measured the heat of solution of liquid bromine in aqueous KBr and in aqueous HBr at 12° , finding, respectively, 2.7 and 2.0 . Correcting these data to 18° , we have obtained for the reaction, $\text{Br}_2 \text{ (liq.)} + \text{Br}^- \text{ (aq.)} = \text{Br}_3^- \text{ (aq.)}$, $Q = 2.7 \pm 0.4$; whence, for $\text{Br}_3^- \text{ (aq.)}$, $Q_f = 31.3$. Linhart¹ determined at various temperatures the equilibrium constant for the reaction, $\text{Br}_2 \text{ (aq.)} + \text{Br}^- \text{ (aq.)} = \text{Br}_3^- \text{ (aq.)}$, and calculated $Q = 1.30$; whence, for $\text{Br}_3^- \text{ (aq.)}$, $Q_f = 31.1$.

Br₅⁻ (aq.). Linhart¹ explained the activity of bromine dissolved in concentrated aqueous KBr as due to the existence of $\text{Br}_5^- \text{ (aq.)}$. This explanation also accounts for the thermal behavior of these solutions. Linhart's data on the temperature coefficient of the equilibrium constant yield, for $\text{Br}_5^- \text{ (aq.)}$, $Q_f = 35.7$. Berthelot's^{151, 105B} calorimetric data lead to practically the same value.

BrO⁻ (aq.). From the values for the heats of formation of NaBrO (aq.), KBrO (aq.), $\text{Na}^+ (\infty)$, and $\text{K}^+ (\infty)$, we have calculated, for $\text{BrO}^- \text{ (aq.)}$, $Q_f = 21.2$ and 21.4 , respectively.

HBrO (aq.). There are no data on the heat of neutralization of HBrO (aq.). Assuming that the heat of the reaction $\text{HBrO (aq.)} = \text{H}^+ \text{ (aq.)} + \text{BrO}^- \text{ (aq.)}$ is the same as that for $\text{HClO (aq.)} = \text{H}^+ \text{ (aq.)} + \text{ClO}^- \text{ (aq.)}$, we have computed, for HBrO (aq.), $Q_f = 25.2$.

HBrO₃ (aq.). Thomsen^{12, 15} measured the heat of the reaction, $\text{HBrO}_3 \text{ (1250)} + 3 \text{ (SnCl}_2 + 2 \text{HCl)} \text{ (500)} = \text{HBr} + 3 \text{SnCl}_4 \text{ (2750)} + 3 \text{H}_2\text{O (liq.)}$, and found $Q = 213.2$; whence we have computed, for $\text{HBrO}_3 \text{ (1250)}$, $Q_f = 11.30$.

BrO₃⁻ (aq.). From the values of Q_f for $\text{KBrO}_3 (\infty)$ and $\text{K}^+ (\infty)$, we have obtained, for $\text{BrO}_3^- (\infty)$, $Q_f = 11.21$.

BrCl (g). From spectroscopic data, Jost³ deduced values of the equilibrium constant at various temperatures, and computed for $\frac{1}{2} \text{Br}_2 \text{ (g)} + \frac{1}{2} \text{Cl}_2 \text{ (g)} = \text{BrCl (g)}$, $Q = 0.75$.

IODINE

I₂ (c). Standard state.

I₂ (g). Vapor pressure data on solid iodine were reported by Baxter and Grose,¹ Baxter, Hickey, and Holmes,¹ and Ramsay and Young.¹ Haber and Kerschbaum¹ measured the vapor pressure at low temperatures. Giauque² critically reviewed the data, and deduced for the heat of sublimation, $V_s = -16.069 + 0.0040(t + 273.1)$, which gives at 18°, -14.91. Earlier calculations were made by Wohl,³ Dewar,¹ and Nernst.¹

I₂ (liq.). Vapor pressure data for liquid iodine were reported by Ramsay and Young,¹ Stelzner and Niederschulte,¹ and Rassow.¹ These data yield for the heat of vaporization, $V = -12.75 + 0.0056(t + 273.1)$. Combination of this equation with that for the heat of sublimation gives for the heat of fusion of solid iodine, $F = -3.3 + 0.0016(t + 273.1)$, or -4.0 at the melting point. See also Rideal.¹

I₂ (aq.). From measurements of the temperature coefficient of solubility, Hartley and Campbell¹ computed $S = -5.0$. Sammet's¹ data yield $S = -4.9$, his own calculated value of -6.37 evidently being in error.

I₂ (C₂H₅OH). Pickering⁸ and Waentig¹ reported for the heat of solution of solid iodine in ethyl alcohol -1.7 and -1.9, respectively. The solution is brown.

I₂ (C₂H₅OC₂H₅). Pickering⁸ and Waentig¹ reported for the heat of solution of solid iodine in ether -1.6 and -2.0, respectively. The solution is brown.

I₂ (CS₂). Pickering⁸ and Waentig¹ measured the heat of solution of solid iodine in carbon disulfide to be -5.0 and -5.2, respectively. The solution is purple.

I₂ (CHCl₃). Pickering⁸ and Waentig¹ found $S = -6.0$ and -5.5, respectively, for the heat of solution of solid iodine in chloroform. The solution is purple.

I₂ (C₆H₆). Pickering⁸ and Waentig¹ reported, for I₂ (c) in benzene, $S = -6.0$ and -4.7, respectively. The solution is purple.

I₂ (CCl₄). Pickering,⁸ for I₂ (c) in carbon tetrachloride, found $S = -5.3$. The solution is purple.

I₂ (pyridine). Waentig¹ found $S = 17$ for the heat of solution of solid iodine in pyridine.

I (g). Density measurements on iodine vapor at high temperatures, which yield values of the equilibrium constant for the reaction, I₂ (g) = 2 I (g), were made by DeVries and Rodebush,¹ Weide and Bichowsky,¹ Braune and Ramstetter,¹ Starck and Bodenstein,¹ Bjerrum,³ and Deville and Troost.² The computed heats of dissociation at 18° from the first five named investigations are, respectively, -31.6, -32, -33.6, -35.4, and -35.7. Lewis and Randall⁵ calculated, from Starck and Bodenstein's¹ data, $D^\circ = -31.7$. Spectroscopic determinations of the energy of dissociation of the normal gaseous I₂ molecule to form 2 normal I atoms lead to much more accurate values than the foregoing ones. Kuhn,¹ Koenigsberger,¹ Gibson and Heitler,¹ and Brown⁴ reported values from

spectroscopic data, the last named investigation giving $D^\circ = -35.40 \pm 0.03$. See also Senfleben and Germer¹ and Kondratjeiv and Leipunsky.¹

The values for the energy states of gaseous monatomic iodine are from Evans¹ and Bacher and Goudsmit.¹

I⁻ (g). Utilizing the data on the lattice energies of CsI and KI, we have computed for the reaction, $\frac{1}{2}\text{I}_2 (\text{c}) + \theta = \text{I}^- (\text{g})$, $Q = 58.4$ and 52.4 , respectively. Sherman¹ calculated for the same reaction, from the data on the alkali iodides, the values 56.4, 52.7, 51.1, 52.3, and 56.3. See also Lennard-Jones.² Recently Mayer³ measured the electrical conductivity of gaseous cesium iodide and of potassium iodide, and deduced values of the equilibrium constant at various temperatures for the reaction $\text{MI} (\text{g}) = \text{M}^+ (\text{g}) + \text{I}^- (\text{g})$. For CsI (g) and KI (g), he calculated, respectively, $D^\circ = 94.8 \pm 0.5$ and -104.6 ± 0.5 . Utilizing our values for CsI (g), Cs⁺ (g), KI (g), and I⁻ (g), one obtains $Q_f = 55.1$ and 52.3 respectively. From a study of the absorption spectra of some alkali iodides, Lederle¹ deduced the unaccountably low values of 48.2, 47.4, and 46.5.

HI (aq.). Thomsen¹⁵ measured the heat of the reaction $\frac{1}{2}\text{Cl}_2 (\text{g}) + \text{KI} (200) = \text{KCl} (200) + \frac{1}{2}\text{I}_2 (\text{c})$. We have recomputed the data of his three experiments, and have obtained, for the above reaction, $Q = 26.26$. Subtracting from the above equation, the difference in the heats of neutralization of HCl (100) and HI (100) with KOH (100), $\text{HCl} (100) + \text{KI} (200) = \text{KCl} (200) + \text{HI} (100)$, $Q = 0.110$, we have obtained for the reaction, $\frac{1}{2}\text{Cl}_2 (\text{g}) + \text{HI} (100) = \text{HCl} (100) + \frac{1}{2}\text{I}_2 (\text{c})$, $Q = 26.15$; whence, for HI (100), $Q_f = 13.23$. Thomsen¹⁵ also measured the heats of the reactions, $\text{KCl} (200) + \text{AgNO}_3 (400) = \text{AgCl} (\text{c}) + \text{KNO}_3 (600)$ and $\text{KI} (200) + \text{AgNO}_3 (400) = \text{AgI} (\text{c}) + \text{KNO}_3 (600)$. From his data on these reactions, we have calculated, for $\text{KCl} (200) + \text{AgI} (\text{c}) = \text{KI} (200) + \text{AgCl} (\text{c})$, $Q = -10.57$. Combining this equation with that for the difference in the heats of neutralization of HCl (100) and HI (100) with KOH (100), we have obtained, for the reaction, $\text{HCl} (100) + \text{AgI} (\text{c}) = \text{HI} (100) + \text{AgCl} (\text{c})$, $Q = -10.46$. And using our values for HCl (100), AgI (c), and AgCl (c), one finds, for HI (100), $Q_f = 13.56$.

A value for the heat of formation of aqueous HI can also be deduced from the following reactions, whose heats were measured by Thomsen¹⁵: $\text{KCl} (200) + \text{HgNO}_3 (200) = \frac{1}{2}\text{Hg}_2\text{Cl}_2 (\text{c}) + \text{KNO}_3 (400)$ and $\text{KI} (200) + \text{HgNO}_3 (200) = \frac{1}{2}\text{Hg}_2\text{I}_2 (\text{c}) + \text{KNO}_3 (400)$. The difference gives, for $\text{KCl} (200) + \frac{1}{2}\text{Hg}_2\text{I}_2 (\text{c}) = \text{KI} (200) + \frac{1}{2}\text{Hg}_2\text{Cl}_2 (\text{c})$, $Q = -9.10$. Combining this with the difference in the heats of neutralization of HCl (100) and HI (100) with KOH (100) gives, for $\text{HCl} (100) + \frac{1}{2}\text{Hg}_2\text{I}_2 (\text{c}) = \frac{1}{2}\text{Hg}_2\text{Cl}_2 (\text{c}) + \text{HI} (100)$, $Q = -8.99$. Using our values for the other three substances in this equation, we have obtained, for HI (100), $Q_f = 13.25$. Utilizing in a similar manner, Thomsen's¹⁵ data on the reaction of $\text{Pb}(\text{NO}_3)_2 (\text{aq.})$ with KCl (aq.) and KI (aq.), respectively, we have computed, for HI (100), $Q_f = 13.21$.

HI (g). The heat of solution of gaseous hydrogen iodide in water was measured by Favre and Silbermann,³ Berthelot and Louguinine,¹ and

Thomsen.¹⁵ Only the data of Thomsen¹⁵ are accurately specified as to temperature and concentration, and we have recomputed them to obtain $S_{200}=19.19$. This gives, for HI (g), $Q_f=-5.91$. The data of Stegmüller,¹ who measured the temperature coefficient of the cell in which the reaction was $\frac{1}{2} \text{H}_2(\text{g}) + \frac{1}{2} \text{I}_2(\text{g}) = \text{HI}(\text{g})$, yield $Q=1.70$; whence, for HI (g), $Q_f=-5.76$. Haber¹ reported for the foregoing reaction $Q=0.096$, calculated from the equilibrium measurements of Bodenstein¹ at high temperatures; but Lewis and Randall⁵ pointed out that neglect of the dissociation of I_2 introduced a false trend in the values of the equilibrium constant. Recently, Gunther and Wekua¹ measured the heat of the reaction, $\frac{1}{2} \text{Cl}_2(\text{g}) + \text{HI}(\text{g}) = \text{HCl}(\text{g}) + \frac{1}{2} \text{I}_2(\text{c})$, to be $Q=27.97$, whence, for HI (g), $Q_f=-5.91$.

HI (liq.). Cottrell¹ found for the heat of solution of liquid HI in water 14.78_{700}^{12} ; whence, for HI (liq.), $Q_f=-1.39$ and $V=-4.42$. The data on the heat of vaporization of liquid HI at the boiling point are: Giauque and Wiebe,³ -4.72 ; Estreicher and Schneer,¹ -4.33 ; Elliott and McIntosh,¹ -4.50 ; and Eucken and Karwat,¹ -4.94 .

HI (c, I), HI (c, II), HI (c, III). The heat of fusion of HI (c, I) and the heat of the two transitions were measured by Giauque and Wiebe³ and Eucken and Karwat.¹ We have selected the values of the former.

I_3^- (aq.). Jones and Kaplan¹ determined the equilibrium constant for the reaction, $\text{I}_3^-(\text{aq.}) = \text{I}_2(\text{aq.}) + \text{I}^-(\text{aq.})$, at 0° and 25° , finding $K=0.00072$ and 0.00140 , respectively. From the temperature coefficient of the equilibrium constant, we have computed, for the above reaction, $Q=-4.22$, whence, for $\text{I}_3^-(\text{aq.})$, $Q_f=12.6$. Pickering⁸ measured the heat of solution of $\text{I}_2(\text{c})$ in 7.6 KI (408), finding $Q=-1.1$. For this concentration, we have calculated from the value of the equilibrium constant that 0.1 of the iodine remains as $\text{I}_2(\text{aq.})$. That is, for the reaction, $\text{I}_2(\text{c}) + 0.9 \text{I}^-(\text{aq.}) = 0.1 \text{I}_2(\text{aq.}) + 0.9 \text{I}_3^-(\text{aq.})$, $Q=-1.1$. From this we have computed, for $\text{I}_3^-(\text{aq.})$, $Q_f=12.5$.

HIO (aq.). Skrabal¹ estimated the following: $\text{I}_2(\text{aq.}) + \text{OH}^-(\text{aq.}) = \text{HIO}(\text{aq.}) + \text{I}^-(\text{aq.})$, $Q=1.0$, and $\text{OH}^-(\text{aq.}) + \text{I}_3^-(\text{aq.}) = \text{HIO}(\text{aq.}) + 2 \text{I}^-(\text{aq.})$, $Q=-5.9$. From these data we have computed, for HIO (aq.), $Q_f=37.3$ and 34.6 , respectively. From the temperature coefficient of the equilibrium constant, Angeleser and Popeser¹ calculated for the reaction, $\text{I}_2(\text{aq.}) + \text{H}_2\text{O}(\text{liq.}) = \text{HIO}(\text{aq.}) + \text{HI}(\text{aq.})$, $Q=-11.7$; whence, for HIO (aq.), $Q_f=38.3$. See also Berthelot.⁴⁶

$\text{IO}^-(\text{aq.})$. This value is computed from that for HIO (aq.), assuming the heat of ionization to be the same as that for HClO (aq.).

HIO_3 (aq.). We have recomputed the data of Thomsen on the reactions, $\text{KI}(600) + 3 \text{HClO}(200) = (\text{HIO}_3 + 2 \text{HCl} + \text{KCl})(1200)$ and $(5 \text{HCl} + 5 \text{KI})(1000) + \text{HIO}_3(\text{aq.}) = 3 \text{I}_2(\text{aq.}) + 3 \text{H}_2\text{O}(\text{liq.}) + 5 \text{KCl}(1000)$, and have obtained, for $\text{HIO}_3(\text{aq.})$, $Q_f=54.61$ and 54.71 , respectively. Berthelot^{42,45} and Skrabal and Buchta¹ also measured the heat of the latter reaction, and their data yield $Q_f=54.8$ and 55.8 , respectively. The data of Luther and Sammet,¹ who determined the temperature coefficient

of the equilibrium constant for the reaction, $6 \text{H}^+ (\text{aq.}) + \text{IO}_3^- (\text{aq.}) + 5 \text{I}^- (\text{aq.}) = 3 \text{I}_2 (\text{aq.}) + 3 \text{H}_2\text{O} (\text{liq.})$, yield, for $\text{HIO}_3 (\text{aq.})$, $Qf = 55.4$. The data of Thomsen¹⁵ on the reaction, $(6 \text{HCl} + 3 \text{SnCl}_2) (\text{aq.}) + \text{HIO}_3 (\text{aq.}) = 3 (\text{SnCl}_4 + \text{HI}) (\text{aq.}) + 3 \text{H}_2\text{O} (\text{liq.})$, yield, for $\text{HIO}_3 (\text{aq.})$, $Qf = 53.8$. Berthelot⁴⁵ and Skrabal and Buchta¹ measured the heat corresponding to the reaction, $3 \text{I}_2 (\text{c}) + 6 \text{OH}^- (\text{aq.}) = \text{IO}_3^- (\text{aq.}) + 5 \text{I}^- (\text{aq.}) + 3 \text{H}_2\text{O} (\text{liq.})$, and their data yield, for $\text{HIO}_3 (\text{aq.})$, $Qf = 54.2$.

$\text{IO}_3^- (\text{aq.})$. We have computed the value of Qf for $\text{IO}_3^- (\infty)$ from the values for $\text{KIO}_3 (\infty)$ and $\text{K}^+ (\infty)$.

$\text{I}_2\text{O}_5 (\text{c})$. The data on the heat of solution of solid iodine pentoxide yield the following values: Ditte,⁴ -1.90 ; Berthelot,⁴⁶ -1.62^{12} ; Thomsen,¹⁵ -1.90 . From Thomsen's data, and the reaction, $\text{I}_2\text{O}_5 (\text{c}) + \text{H}_2\text{O} (\text{liq.}) = 2 \text{HIO}_3 (\text{aq.})$, we have computed, for $\text{I}_2\text{O}_5 (\text{c})$, $Qf = 42.73$.

$\text{HIO}_3 (\text{c})$. The data on the heat of solution of $\text{HIO}_3 (\text{c})$ in water yield the following values: Ditte,⁴ -2.24 ; Berthelot,⁴⁶ -2.67^{12} ; Thomsen,¹⁵ -2.17 . Using Thomsen's value we have obtained, for $\text{HIO}_3 (\text{c})$, $Qf = 56.77$.

$\text{I}_2\text{O}_5 \cdot \text{HIO}_3 (\text{c})$. Berthelot⁴⁶ reported for $\text{I}_2\text{O}_5 \cdot \text{HIO}_3 (\text{c})$, $S = -4.29^{12}$, and for $\text{I}_2\text{O}_5 \cdot 2 \text{HIO}_3 (\text{c})$, $S = -5.72^{12}$. Our best present information is that only the former hydrate of I_2O_5 exists. Berthelot's $\text{I}_2\text{O}_5 \cdot 2 \text{HIO}_3 (\text{c})$ was probably a mixture.

$\text{H}_5\text{IO}_6 (\text{aq.})$. Thomsen¹⁵ measured the heat of reduction of $\text{H}_5\text{IO}_6 (\text{aq.})$ with aqueous stannous chloride acidified with HCl , and his data yield, for $\text{H}_5\text{IO}_6 (\text{aq.})$, $Qf = 183.0$.

$\text{H}_5\text{IO}_6 (\text{c})$. Thomsen¹⁵ found $S = -1.38_{2000}$.

$\text{H}_4\text{IO}_6^- (\text{aq.})$, $\text{H}_3\text{IO}_6^{2-} (\text{aq.})$, $\text{H}_2\text{IO}_6^{3-} (\text{aq.})$, $\text{HIO}_6^{4-} (\text{aq.})$, $\text{IO}_6^{5-} (\text{aq.})$. Thomsen¹⁵ measured the heat of neutralizing $\text{H}_5\text{IO}_6 (\text{aq.})$ with 1, 2, 3, and 5 moles of $\text{KOH} (\text{aq.})$. The data are extraordinary in that Thomsen found a much smaller heat for the first mole of KOH than for the second, which is quite contrary to the usual behavior. It is difficult to tell which ions really exist in the solution and the values for the foregoing ions are computed in a purely formal manner.

$\text{ICl} (\text{g})$. McMorris and Yost¹ studied the equilibrium, $\frac{1}{2} \text{Cl}_2 (\text{g}) + \frac{1}{2} \text{I}_2 (\text{g}) = \text{ICl} (\text{g})$, at various temperatures, and deduced, for $\text{ICl} (\text{g})$, $Qf = -3.13$. The energy of dissociation of $\text{ICl} (\text{g})$ into normal iodine and chlorine atoms has been determined from spectroscopic data by Wilson,³ Gibson and Ramsperger,¹ Patkowski and Curtis,¹ and Brown and Gibson.¹ The data of Brown and Gibson¹ are the most accurate and give, for $\text{ICl} (\text{g})$, $Qf = -3.46$.

$\text{ICl} (\text{liq.})$. McMorris and Yost,¹ from vapor pressure data on liquid ICl , computed $V = -9.49$; whence, for $\text{ICl} (\text{liq.})$, $Qf = 6.03$. Thomsen¹⁵ measured the heat of formation of $\text{ICl} (\text{liq.})$ and found $Qf = 5.85$.

$\text{ICl} (\text{c}, \alpha)$. Berthelot^{64, 140} measured directly the heat of formation of $\text{ICl} (\text{c}, \alpha)$, finding $Qf = 6.9$; and also measured its heat of solution in aqueous sulfurous acid, which latter data lead to the value 6.6. The

data on the heat of fusion of ICl (c, α) are: Tanatar,⁵ -2.32 ; Stortebeker,¹ -2.66 ; Berthelot,^{64, 140} -2.43 . These values, coupled with that for ICl (liq.), $Qf=6.03$, yield, for ICl (c, α), $Qf=8.35$, 8.69 , and 8.46 , respectively.

ICl_3 (c). For ICl_3 (c), Thomsen¹⁵ reported $Qf=21.5$; Berthelot⁶⁴ found, by direct combination, $Qf=15.5$, and by the reaction with aqueous sulfurous acid, $Qf=17.1$.

IBr (g). From the data of Bodenstein and Schmidt¹ and Muller¹³ on the equilibrium, $\frac{1}{2} \text{Br}_2$ (g) + $\frac{1}{2} \text{I}_2$ (g) = IBr (g), we have computed, for IBr (g), $Qf=-9.6$. The spectroscopic data of Cordes and Sponer¹ on the energy of dissociation of IBr (g) into normal iodine and bromine atoms yield, for IBr (g), $Qf=-10.3$.

IBr (liq.). By direct measurement, Berthelot^{64, 140} found $Qf=2.47$.

BrCl (g). We have estimated this value.

BrCl (liq.). We have estimated this value.

ELEMENT 85

X (c). Standard state.

SULFUR

S (c, rhombic). Standard State.

S (c, monoclinic). The heat of transformation of monoclinic to rhombic sulfur was measured by Bronsted,³ Mitscherlich,² Tammann,^{2, 3} Lewis and Randall,¹ Wigand,¹ and Mondain-Monval.^{1, 4} Using Lewis and Randall's⁵ values for the heat capacities, we have found that Bronsted's³ data yield, for the transformation, $T=0.120-0.0005(t+273.1)-0.00000125(t+273.1)^2$; whence, at 18° , $T=-0.080$, and at 95° , the normal transition temperature, $T=-0.088$. Mondain-Monval^{1, 4} found $T=-0.087$.

S (liq., μ), S (liq., λ). Liquid sulfur is a mixture of at least two forms, soluble S (λ) and insoluble S (μ). At the melting point there is 95 per cent of the former. Lewis and Randall¹ found, for the heat of fusion of rhombic sulfur, $F=-0.478^{112}$. For the heat of fusion of monoclinic sulfur, the following data were reported: Mondain-Monval,⁴ -0.297^{119} ; Person,¹ -0.30^{115} ; Trautz,⁶ -0.284^{119} ; Iitaka,¹ -0.429^{119} ; Wigand,¹ -0.334^{119} . At 119° liquid sulfur contains 4 per cent of S (μ). Taking Wigand's¹ value, we have computed, for S (c, monoclinic) = S (liq., λ), $F=-0.35^{119}$; and utilizing the heat capacity data of Lewis and Randall,¹ we have calculated, for S (liq., λ), $Qf=-0.33$.

For the heat of transformation, S (liq., λ) = S (liq., μ). Lewis and Randall¹ reported -0.416^{25} ; Mondain-Monval,⁴ -0.9^{160} ; Berthelot,¹ -0.86^{185} . Taking Lewis and Randall's value, we have computed, for S (liq., μ), $Qf=-0.75$.

S_8 (CS_2). Berthelot^{1, 130} measured the heat of solution of sulfur in carbon disulfide.

S (S_2Cl_2). The heat of solution of sulfur in liquid S_2Cl_2 was found

by Trautz⁶ to be -1.3 to -3.0 , and by Thomsen,¹⁵ -0.83 ; the data on the variation of solubility with temperature yield -1.5 .

$S_8(g)$, $S_6(g)$, $S_2(g)$. Sulfur gas is a mixture of S_8 and its dissociation products. The gas in equilibrium with the liquid at 150° is practically all S_8 . Vapor pressure data on liquid sulfur were reported by Ruff and Graf,¹ Bodenstein,⁴ Gruener,¹ and Mathies¹; and these data were used by Preuner and Schupp¹ to compute $V = -20.0^{150}$. The vapor pressure data of West and Menzies¹ yield $V = -20.5^{150}$. Awbery¹ measured directly the heat of vaporization at the boiling point to be -20.2 .

The isotherms of sulfur vapor indicate the existence of at least two molecular species in addition to S_8 . Arbitrarily selecting the species as S_8 , S_6 , and S_2 , we have interpreted the data of Mitscherlich¹ and Preuner and Schupp¹ to give the following values: $3 S_8(g) = 4 S_6(g)$, $Q = -29$; $S_6(g) = 3 S_2(g)$, $Q = -64$.

Data on the vapor pressure of sulfur above the boiling point were reported by Barus,^{1, 2} Greuner,¹ Rassow,¹ Regnault,^{6, 7} Ruff and Graf,¹ and Menzies.¹

There is an indirect but more certain method of calculating the heat of formation of $S_2(g)$ than the foregoing. Lewis and Randall^{3, 5} reviewed the equilibrium data of Preuner,¹ Preuner and Schupp,¹ and Randall and Bichowsky¹ on the reaction, $H_2(g) + \frac{1}{2} S_2(g) = H_2S(g)$, and concluded that $Q = -19.6$. Using our value of Q_f for $H_2S(g)$, we have obtained, for $S_2(g)$, $Q_f = -28.6$. Lewis and Randall⁵ also reviewed the equilibrium data leading to the reaction, $S(c, \text{rhombic}) + H_2(g) = H_2S(g)$, and calculated, for $S_2(g)$, $Q_f = -29.7$.

The energy states of the gaseous S_2 molecule are evaluated from the band spectral data of Christy and Naude.¹ The spectrum of S_2 has also been studied by Henri,³ Henri and Teves,¹ Rosen,¹ and Kondratjew.¹ See also Jevons.¹

$S(g)$. From data on a bomb reaction involving the combustion of hydrogen sulfide, Budde¹ deduced for the reaction, $S_2(g) = 2 S(g)$, $Q = -120.2^{450}$. However, Bjerrum³ pointed out that Budde's results may be interpreted just as well by assuming that the heat absorbing side reaction is not the dissociation of S_2 but the reaction of sulfur with water. The foregoing value, therefore, is not a reliable one. Bjerrum³ estimated, from Budde's¹ data, $D = -80$. From vapor density data, von Wartenberg³ estimated $D = -90$. Nernst⁴ found that S_2 is 80 per cent dissociated at 2200° . Computing the free energy change from this value and utilizing the entropy and heat capacity values given by Lewis and Randall,¹ we have obtained $D = -48$. The heat of formation of gaseous monatomic sulfur can be evaluated accurately from spectroscopic data. For the energy of dissociation of normal $S_2(g)$ into normal S atoms, Christy and Naudé,¹ reported the value 4.45 volt-electrons. See also Henri³ and Kondratjew.¹

The electronic energy states of the sulfur atom are evaluated from the data of Fowler,³ Birge,² Hopfield,^{2, 3} and Runge and Paschen.¹ See also

Frerichs³ and Bacher and Goudsmit.¹ The energies of the sulfur atom in various stages of ionization are taken from Ingram,^{1, 2} Millikan and Bowen,^{1, 2} Bowen,⁴ and Bowen and Millikan.^{1, 2}

$S^-(g)$. The electron affinity of the sulfur atom is calculated in the same manner as for the oxygen atom. Sherman¹ reported for the lattice energies of MgS , CaS , SrS , and BaS , the values 778.3, 721.8, 687.4, and 655.9, respectively. Lennard-Jones¹ and Taylor¹ gave for MgS and CaS , 784 and 728, respectively. Our individual values for the electron affinity of $S(g)$, calculated from the foregoing values, are different from those computed by Sherman,¹ but our average value is the same as his, namely, -79.5 for the reaction, $S(g) + 2\theta = S^-(g)$.

$SO_2(g)$. Calorimetric determinations of the heat of formation of sulfur dioxide from solid sulfur and oxygen were made by Dulong,² Andrews,¹⁴ Favre and Silbermann,¹ Hess,⁷ Thomsen,¹⁵ Berthelot,^{45, 65} Giran,⁶ Frost,¹ and Eckman and Rossini.¹ The first four investigations are of historical interest only.

Thomsen¹⁵ burned solid sulfur in a stream of oxygen gas at constant pressure in his calorimeter. The appreciable amounts of sulfur trioxide which were formed along with the sulfur dioxide in Thomsen's experiments were determined by weighing, and a heat correction was applied. The amount of sulfur dioxide was determined by absorbing it in strong chromic acid solution and weighing. Thomsen's data yield $Q = 71.08$ and 71.72 for the heats of combustion of solid rhombic and solid monoclinic sulfur, respectively, in oxygen to form gaseous sulfur dioxide. These values, incidentally, give much too large (about 7 times) a value for the heat of transition of monoclinic to rhombic sulfur.

Berthelot^{45, 65} burned rhombic sulfur in oxygen in a bomb at constant volume. The amounts of sulfur dioxide along with the lesser amounts of sulfur trioxide were absorbed and determined by titration with iodine exactly equivalent to the amount of sulfur burned. In another series, Berthelot used aqueous potassium hydroxide to absorb the products of combustion, titrating afterwards with iodine. His data from the two series of experiments yield, respectively, $Q = 69.4$ and 69.1 , for the reaction, $S(c, \text{rhombic}) + O_2(g) = SO_2(g)$. Ferguson¹ reviewed Berthelot's data and discarded the results of his second series on the grounds of unreliability of the analytical method.

Giran⁶ determined the heat of combustion of sulfur in a bomb at constant volume with various pressures of oxygen. The observed heats of combustion varied linearly from 70.4 at 2.5 atmospheres to 81.1 at 45 atmospheres. Extrapolation to zero pressure yields $Q = 69.5$.

Frost¹ carried out experiments on two reactions: $S(c, \text{rhombic}) + \frac{2}{3} KIO_3(aq.) + O_2(g) + \frac{4}{3} H_2O(liq.) = I_2(c) + \frac{4}{3} H_2SO_4(aq.) + \frac{1}{3} K_2SO_4(aq.)$, and $SO_2(liq.) + \frac{2}{3} KIO_3(aq.) + \frac{4}{3} H_2O(liq.) = I_2(c) + \frac{4}{3} H_2SO_4(aq.) + \frac{1}{3} K_2SO_4(aq.)$. The difference gives the reaction, $S(c, \text{rhombic}) + O_2(g) = SO_2(liq.)$. For the first reaction Frost¹ found at constant volume $Q = 133.2^{23.9}$, $132.7^{26.2}$, and $132.4^{24.3}$, using about 0.03 mole of sulfur in

each experiment. Frost¹ found that these results showed a trend much greater than the calorimetric error, and selected $Q=134$. For the second reaction Frost¹ found, at constant volume, $Q=60.06$, 60.01 , and 60.03 . Thus for the third reaction above these data yield $Q=74.6$ at constant pressure. Taking the heat of vaporization of liquid sulfur dioxide as -6.0 , we have obtained from these data, for SO_2 (g), $Q_f=68.6$.

Eckman and Rossini¹ made a careful determination of the heat of formation of gaseous sulfur dioxide under conditions which completely favored a pure reaction,—no sulfur trioxide being formed. This was accomplished by burning oxygen gas in an excess of sulfur vapor at constant pressure in a calorimeter. The reaction took place in a flame where the stream of oxygen gas entered the chamber containing the sulfur vapor. The amount of reaction was determined from the mass of sulfur which disappeared, and, as a check, from the amount of sulfur dioxide formed by absorbing it in a sodium hydroxide-asbestos mixture and weighing. Their data yield, for SO_2 (g), $Q_f=70.92 \pm 0.05$.

SO_2 (liq.). Vapor pressure data were reported by Faraday,³ Young,² Cardoso and Fiorentino,¹ Henning and Stock,¹ Mund,¹ Mills,¹ Bergstrom,^{2,3} Burrell and Robertson,¹ Regnault,⁷ Pictet,¹ and Blumcke.¹ See also Antione.³ The heat of vaporization of liquid sulfur dioxide was measured directly by Eucken,^{2,3} Estreicher and Schnee,¹ Chappuis,² Estreicher,² Mathias,¹ Schnee,¹ Cailletet and Mathias,^{1,2} and Smith.¹ The last named found $V=-6.07^{10}$.

SO_2 (c). Vapor pressure data on solid and liquid sulfur dioxide were reported by Bergstrom,^{2,3} Burrell and Robertson,¹ and Steele and Bagster.¹ These data yield for the heats of sublimation and vaporization of the solid and liquid near the melting point, -8.56 and -6.64 , respectively; whence $F=-1.9$ at the melting point.

SO_2 (aq.). From the vapor pressure data of Lindner^{1,2} on aqueous solutions of sulfur dioxide, Bichowsky³ deduced the following values for the heat of solution of SO_2 (g) in water: 6.68_{90} ; 6.90_{200} ; 6.97_{290} ; 7.70_{1500} ; 9.13_{6600} . These values are in fair agreement with the recent data of Stiles and Felsing,¹ who measured directly the heat of solution, and gave $Q=0.911+1.1053 \log n$, where n is the number of moles of water per mole of SO_2 . Ramstetter and Hantke¹ reported $S=8.02_{40}$. Values computed from the vapor pressure data of Maass and Maass¹ are in accord with those of Stiles and Felsing.¹ Data on the solubility of SO_2 in water were reported by Hudson,¹ Roozeboom,¹ Burrell and Robertson,¹ McCrae and Wilson,¹ Freeze,¹ and Oman.¹ The old direct calorimetric data of Berthelot,⁹² de Forcrand,⁴ and Favre and Silbermann³ are now of historical interest only. Thomsen¹⁵ measured the heat of solution of SO_2 (liq.) in water to be 1.444_{210} and 1.564_{310} .

SO_3^{--} (aq.). From the various values for Na_2SO_3 (aq.) and K_2SO_3 (aq.), we have computed, for SO_3^{--} (aq.), $Q_f=148.2$, 149.2 , and 150.7 , respectively.

$\text{S}_2\text{O}_8^{--}$ (aq.). Berthelot^{63, 107} measured the heat of the reaction,

$\text{BaS}_2\text{O}_8 \text{ (aq.)} + \text{H}_2\text{SO}_4 \text{ (220)} = \text{BaSO}_4 \text{ (c)} + \text{H}_2\text{S}_2\text{O}_8 \text{ (aq.)}$. From our values for the last three substances, we have computed, for $\text{BaS}_2\text{O}_8 \text{ (aq.)}$, $Q_f = 451.7$; whence, taking for $\text{Ba}^{++} \text{ (aq.)}$, $Q_f = 128.4$, one finds for $\text{S}_2\text{O}_8^{--} \text{ (aq.)}$, $Q_f = 323.3$.

$\text{HSO}_3^- \text{ (aq.)}$. From the values of the heats of formation of $\text{NaHSO}_3 \text{ (aq.)}$ and $\text{KHSO}_3 \text{ (aq.)}$, we have calculated, for $\text{HSO}_3^- \text{ (aq.)}$, $Q_f = 148.8$ and 149.4 , respectively.

$\text{S}_2\text{O}_5^{--} \text{ (aq.)}$. We have taken equal to zero the heat of the reaction, $2 \text{HSO}_3^- \text{ (aq.)} = \text{H}_2\text{O (liq.)} + \text{S}_2\text{O}_5^{--} \text{ (aq.)}$.

$\text{SO}_2 \cdot 7 \text{H}_2\text{O (c)}$. The solid hydrate of SO_2 is now usually accepted as having 7 moles of water. The dissociation pressure of this compound was measured at various temperatures by Villard^{2, 10} and Roozeboom.⁴ The data of the latter yield, for $\text{SO}_2 \cdot 7 \text{H}_2\text{O (c)} = \text{SO}_2 \text{ (g)} + 7 \text{H}_2\text{O (c)}$, $Q = -7.78$ at 0° .

SO (g) . The band spectra of sulfur dioxide indicate the existence of a diatomic molecule. From a study of the predissociation limits in sulfur dioxide, Henri² and Henri and Wolff¹ deduced the following: $\text{SO}_2 \text{ (g)} = \text{SO (g)} + \text{O (g)}$, $Q = -112.5$; $\text{SO (g)} = \text{S (g)} + \text{O (g)}$, $Q = -148$. These values yield for SO (g) , $Q_f = 17.5$ and 23 , respectively. Martin¹ carefully reinvestigated these spectra, and concluded that the normal state of SO is $^3\Sigma$ and that it dissociates into a normal S atom and a normal O atom with $D^\circ = -118.2$. Hence, for SO (g) , $Q_f = -6.3$.

$\text{H}_2\text{S (g)}$. Thomsen¹⁵ determined the heat of formation of $\text{H}_2\text{S (g)}$ by burning it in oxygen in his flame calorimeter. The reaction is not a clear cut one, there being a considerable quantity of sulfuric acid spray formed along with the SO_2 and H_2O . For $\text{H}_2\text{S (g)}$, Thomsen¹⁵ reported $Q_f = 2.73$. We have carefully recomputed his calorimetric and analytical data and have deduced for the reaction, $\text{H}_2\text{S (g)} + \frac{3}{8} \text{O}_2 \text{ (g)} = \text{H}_2\text{O (liq.)} + \text{SO}_2 \text{ (g)}$, $Q = 134.10$ whence, for $\text{H}_2\text{S (g)}$ $Q_f = 5.2$. Thomsen¹⁵ also measured the heat of the reaction $\text{I}_2 \text{ (c)} + \text{HI (aq.)} + \text{H}_2\text{S (g)} = 3 \text{HI (aq.)} + \text{S (solid)}$. The sulfur precipitated was the usual plastic form, the heat of inversion of which into rhombic sulfur we have taken as 0.3 (following the discussion of Pollitzer¹). For the above reaction, Thomsen¹⁵ found $Q = 21.6$, whence we have computed, for $\text{H}_2\text{S (g)}$, $Q_f = 5.5$. Pollitzer¹ measured the equilibria in the reaction, $\text{I}_2 \text{ (c)} + \text{H}_2\text{S (g)} = 2 \text{HI (g)} + \text{S (c, rhombic)}$, at various temperatures, and gave $Q = 17.20$; whence, for $\text{H}_2\text{S (g)}$, $Q_f = 5.4$. Another value for the heat of formation of hydrogen sulfide is obtained from the equilibrium data on the reaction, $\text{S (c, rhombic)} + \text{H}_2 \text{ (g)} = \text{H}_2\text{S (g)}$, which are discussed by Lewis and Randall.⁵ These last data yield, for $\text{H}_2\text{S (g)}$, $Q_f = 5.0$.

$\text{H}_2\text{S (liq.)}$. By direct measurement, Estreicher and Schneer¹ found $V = -4.49$ ^{-61.4}; Elliott and McIntosh¹ gave $V = -4.68$. The vapor pressure data of Cailletet and Bordet,¹ Regnault,⁶ Maass and McIntosh,² Steele and Bagster,¹ and Steele, McIntosh, and Archibald¹ yield $V = -4.5$.

$\text{H}_2\text{S (c)}$. The vapor pressure data of Maass and McIntosh² yield

−4.95 for the heat of sublimation of H_2S (c). See also Steele, McIntosh, and Archibald.¹

$\text{H}_2\text{S} \cdot 6 \text{H}_2\text{O}$ (c). The vapor pressures of this solid hydrate in the presence of a solution of H_2S in H_2O and of H_2O in H_2S , which two liquid solutions are immiscible, were measured by Caillietet and Bordet,¹ McLaughlan,¹ Scheffer,^{1, 6} Scheffer and Meyer,^{1, 2} and Schrienemaker.¹ de Forcrand and Fonzes-Diacon¹ computed, from the foregoing data, $Q = -16.5$ for the reaction $\text{H}_2\text{S} \cdot 6 \text{H}_2\text{O}$ (c) = $6 \text{H}_2\text{O}$ (liq.) + H_2S (g).

H_2S (aq.). Thomsen¹⁵ found, by direct measurement, the heat of solution of H_2S (g) in water to be 4.75. The solubility data of Scheffer^{1, 6} and Winkler⁷ yield 4.56 and 4.86, respectively.

S^- (aq.). From the values of the heats of formation of Na_2S (∞), Na^+ (∞), K_2S (∞), and K^+ (∞), we have computed, for S^- (∞), $Qf = -9.86$ and -10.14 , respectively.

S_2^- (aq.), S_3^- (aq.), S_4^- (aq.). From the values of Qf for the aqueous polysulfides of sodium, we have obtained the values for these ions.

HS^- (aq.). From the values of Qf for NaHS (∞), Na^+ (∞), KHS (∞), and K^+ (∞) we have found, for HS^- (∞), assuming no dissociation, $Qf = 3.95$ and 3.85 , respectively.

H_2S_5 (liq.). Sabatier¹ found for the reaction, H_2S_5 (liq.) = H_2S (g) + 4S (solid), $Q = 2.7$. Assuming that the sulfur formed was rhombic, one finds, for H_2S_5 (liq.), $Qf = 2.6$.

H_2S_2 (liq.). We have estimated for the reaction, H_2S_2 (liq.) + 3S (c) = H_2S_5 (liq.), $Q = 3$; whence, for H_2S_2 (liq.), $Qf = -0.4$. This value lies between those for H_2S (liq.) and H_2S_5 (liq.).

H_2S_2 (g). Butler and Maass¹ measured the heat of vaporization of liquid H_2S_2 .

H_2S_2 (c). Butler and Maass¹ measured the heat of fusion.

H_2SO_4 (aq.). Thomsen¹⁵ measured the heat of reaction of gaseous chlorine with aqueous sulfur dioxide to form a mixture of aqueous hydrochloric and sulfuric acids. We have recomputed in detail the data of Thomsen's three experiments on this reaction, and have obtained, for SO_2 (2400) + Cl_2 (g) + $2\text{H}_2\text{O}$ (liq.) = 2HCl (800) + H_2SO_4 (800), $Q = 73.84 \pm 0.10$; whence, anticipating the value for the heat of dilution, one finds, for H_2SO_4 (200), $Qf = 210.3$. Berthelot,^{45, 135, 136} measured the heat of reaction of liquid bromine with aqueous sulfur dioxide, and also that of solid bromine with aqueous sulfur dioxide. His data yield, respectively, for H_2SO_4 (200?), $Qf = 212.6$ and 210.3 . Mixer¹⁵ measured in a bomb calorimeter the heat of reaction of rhombic sulfur with sodium peroxide, S (c, rhombic) + $3\text{Na}_2\text{O}_2$ (c) = Na_2SO_4 (c) + $2 \text{Na}_2\text{O}$ (c), and found $Q = 168.6$. Utilizing our values for the heats of formation of Na_2O_2 (c), Na_2O (c), the heat of solution of Na_2SO_4 (c) in $400 \text{H}_2\text{O}$, the heat of neutralization of H_2SO_4 (200) with 2NaOH (100), and the heat of formation of NaOH (100), we have computed, for H_2SO_4 (200), $Qf = 210.4$. Utilizing the data obtained by Frost¹ on the reaction between liquid SO_2 and aqueous KIO_3 , which has been discussed under the section on SO_2 (g), we have computed,

for H_2SO_4 (200), $Q_f=213.7$. This value is given little weight because of the large heats of mixing involved. Roth, Grau, and Meichsner¹ recently measured the heat of reaction of aqueous hydrogen peroxide with gaseous sulfur dioxide, and the heat of decomposition of aqueous hydrogen peroxide into water and oxygen. Combining their data on these two reactions, we have computed, for SO_2 (g) + H_2O (liq.) + $\frac{1}{2}\text{O}_2$ (g) = H_2SO_4 (800), $Q=73.09$; whence for H_2SO_4 (200), $Q_f=211.6$. The data of Hess^{7, 9} are of historical interest only.

The heat of dilution of aqueous sulfuric acid was measured by many investigators. The data of Favre and Silbermann,³ Favre and Quillard,¹ Thomsen,¹⁵ Pfaundler,⁵ Pickering,⁹ and Rümelin,¹ were summarized by Brönsted.⁷ The values deduced by Brönsted⁷ have been experimentally verified and extended by Grau and Roth,¹ who reported values from 1 to 20,000 H_2O . Other data are given by Naudé,² Berthelot,^{48, 111} Muller,⁷ and Mathias.¹ See also Bose,² Wilson,¹ and Porter.² The value of Q_f for H_2SO_4 (∞) is taken as equal to that for SO_4^{--} (∞).

H_2SO_4 (liq.). Brönsted⁷ and Grau and Roth¹ measured the heat of solution of liquid sulfuric acid in water and of water in liquid sulfuric acid. Their data yield, respectively, for H_2SO_4 (liq.), $Q_f=193.73$ and 193.75 . For the heat of solution of liquid sulfuric acid, Berthelot⁴⁸ found 16.92_{150} and Thomsen¹⁵ 17.85_{1600} .

H_2SO_4 ($\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$). Hantzsch¹ measured the heat of solution of liquid sulfuric acid in diethyl ether.

H_2SO_4 (c). The data on the heat of fusion of solid sulfuric acid are: Berthelot,^{3, 6, 132} -0.86 ; Pickering,¹³ -2.35 ; Hantzsch,² -2.258 ; Knietzsch (see Hantzsch²), -2.24 ; Brönsted,⁷ $-2.55^{10.5}$.

$\text{H}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ (c). The data on the heat of fusion of the hydrate are: Berthelot,^{3, 6, 132} -3.680 ; Hammerl,³ -3.420 , -3.536 ; Pickering,¹³ -3.92 ; Brönsted,⁷ $-4.290-0.0188 t$. Brönsted's⁷ data yield $F=-4.45$ at the melting point, 8.60° .

SO_4^{--} (aq.) From the values of the heats of formation of Li_2SO_4 (∞), Li^+ (∞), Na_2SO_4 (∞), Na^+ (∞), K_2SO_4 (∞), and K^+ (∞), we have computed, for SO_4^{--} (∞), $Q_f=215.71$, 215.76 , and 215.94 , respectively.

SO_3 (liq.). The data on the heat of solution of liquid sulfur trioxide in water are: Thomsen,¹⁵ 39.17_{1600} ; Giran,³ 39.4_{400} ; Grau and Roth,² 41.18_{5000} .

SO_3 (g). Berthelot⁶⁶ found for the heat of solution of gaseous sulfur trioxide in water, $S=49.2_{200}$, whence, for SO_3 (g), $Q_f=93.9$. Giran³ reported, for the heat of vaporization of liquid sulfur trioxide, $V=-9.4$; Grau and Roth² found $V=-10.0 \pm 0.4$. From the latter value we have computed, for SO_3 (g), $Q_f=94.2$. The vapor pressure data of Berthout,¹ Smits and Schoenmaker,^{1, 2} and Grau and Roth² yield, respectively, $V=-10.37$, -10.40 , and -10.22 . The average of these values yields, for SO_3 (g), $Q_f=93.9$. From a study of predissociation in the absorption spectra of gaseous sulfur trioxide, Dutt¹ deduced SO_3 (g) = SO_2 (g)

+O (g) (3P), $D^{\circ} = -86.7$ and $SO_3(g) = SO_2(g) + O(g)$ (1D_2), $D^{\circ} = -125$. From these data we have computed, for $S_2O_3(g)$, $Q_f = 99$ and 92 , respectively. The data of Hess⁷ on sulfur trioxide are of historical interest only.

$SO_3(c, \alpha)$, $SO_3(c, \beta)$. There are two crystalline forms of solid sulfur trioxide, the "ice-like" or α form which melts sharply at 16.8° , and the "wool-like" or β form which is stable above 16.8° but does not appear to be well defined. The vapor pressure data of Smits and Schoenmaker,^{1, 2} yield -12.1 for the heat of sublimation of $SO_3(c, \alpha)$, whence $Q_f = 106.0$. Berthelot,^{6, 9} and Grau and Roth¹ measured the heat of solution of $SO_3(c, \beta)$ in water. Their data yield $Q_f = 105.8$ and 105.2 , respectively. Grau and Roth¹ showed that the heat of solution varied considerably with the sample, indicating that the "wool-like" or β form of sulfur trioxide may be a mixture of varying composition.

$H_2S_2O_7(c)$. Thomsen¹⁵ measured the heat of solution.

$H_2S_2O_7(liq.)$. Auerbach¹ measured the heat of fusion of the solid.

$H_2S_2O_8(aq.)$. Berthelot^{63, 107} measured the heats of reaction of $H_2S_2O_8(220)$ with $(FeSO_4 + H_2SO_4)(440)$ and of $H_2O_2(aq.)$ with $(FeSO_4 + H_2SO_4)(440)$. The difference in these heats of reaction gives that for $H_2S_2O_8(220) + 2H_2O(liq.) = 2H_2SO_4(220) + H_2O_2(aq.)$. Berthelot's data on two preparations of aqueous persulfuric acid yield for this reaction $Q = 13.5$ and 13.4 , respectively. Berthelot^{63, 107} also obtained data on two other series of reactions, using instead of $H_2S_2O_8(220)$, the mixtures $((NH_4)_2S_2O_8 + H_2SO_4)(aq.)$ and $(K_2S_2O_8 + H_2SO_4)(aq.)$, respectively. These data give for the foregoing reaction, $Q = 13.2$ and 13.0 , respectively. Taking the value 13.4 , we have computed, for $H_2S_2O_8(aq.)$, $Q_f = 318.5$. Berthelot's^{63, 107} data on the reaction of aqueous sulfurous acid with aqueous persulfuric acid yield a value for the heat of formation of the latter that is in accord with the foregoing.

$S_2O_7(c)$. Giran,⁶ by an indirect method of which he does not give the details, computed the heat of solution of solid persulfuric acid anhydride to be 56.7 .

$S_2O_8^{--}(aq.)$. This value is obtained from those for $Na_2S_2O_8(aq.)$ and $Na^+(aq.)$.

$S_2O_6^{--}(aq.)$. This value is obtained from those for $K_2S_2O_6(aq.)$ and $K^+(aq.)$.

$H_2S_2O_6(aq.)$. Thomsen¹⁵ found $N_{1200} = 27.07$.

$S_3O_6^{--}(aq.)$. From the values for $Na_2S_3O_6(aq.)$ and $K_2S_3O_6(aq.)$, we have found, for $S_3O_6^{--}(aq.)$, $Q_f = 279.6$ and 278.3 , respectively.

$S_4O_6^{--}(aq.)$. The value is obtained from those for $Na_2S_4O_6(aq.)$ and $Na^+(aq.)$.

$H_2S_4O_6(aq.)$. Assuming tetrathionic acid to be completely ionized, one finds Q_f for $H_2S_4O_6(aq.)$ equal to that for $S_4O_6^{--}(aq.)$.

$S_5O_6^{--}(aq.)$. This value is obtained from those for $K_2S_5O_6(aq.)$ and $K^+(aq.)$.

$S_2O_4^{--}(aq.)$. Berthelot⁴⁰ measured the heat of reaction between oxy-

gen gas and a sodium sulfite solution freshly reduced by zinc. Presumably the active ion is $\text{S}_2\text{O}_4^{--}$; and, if so, the reaction is $\text{S}_2\text{O}_4^{--}(\text{aq.}) + \text{H}_2\text{O}(\text{liq.}) + \frac{1}{2} \text{O}_2(\text{g}) = 2\text{HSO}_3^-(\text{aq.})$. Berthelot found $Q = 67.8$, whence we have computed, for $\text{S}_2\text{O}_4^{--}(\text{aq.})$, $Q_f = 161.8$.

$\text{S}_2\text{Cl}_2(\text{liq.})$. For the heat of formation of liquid S_2Cl_2 , Thomsen¹⁵ found 14.26; Trautz,⁶ 14.5; and Ogier,⁶ 17.6.

$\text{S}_2\text{Cl}_2(\text{g.})$. For the heat of vaporization of liquid S_2Cl_2 , Ogier⁶ found -6.7 by direct measurement; Orndorff and Terrasse¹ reported -8.7 from data on boiling point elevation; Harvey and Schuette¹ -8.65 from vapor pressure data; and Trautz, Rick, and Acker¹ -8.5 from vapor pressure data. Gaseous S_2Cl_2 is partly dissociated.

$\text{S}_2\text{Cl}_4(\text{liq.})$, $\text{SCL}_4(\text{liq.})$. Trautz⁹ and Ogier⁶ measured the heat of solution of chlorine in liquid S_2Cl_2 , and, for the more or less imaginary reaction, $\text{S}_2\text{Cl}_2(\text{liq.}) + \text{Cl}_2(\text{g}) = \text{S}_2\text{Cl}_4(\text{liq.})$, reported $Q = 9.8$ and 5.8 , respectively. Absorption of 3 moles of Cl_2 per mole of S_2Cl_2 leads to values of $Q = 12$ to 14 for the assumed reaction $\text{S}_2\text{Cl}_2(\text{liq.}) + 3 \text{Cl}_2(\text{g}) = 2 \text{SCL}_4(\text{liq.})$. Thomsen¹⁵ and Beckmann⁵ noted that heat was evolved in the first reaction. Aten¹ quoted their results to prove the existence of S_2Cl_4 , but the evidence in favor of the existence of S_2Cl_4 is not convincing, especially since the accepted freezing point diagram for the Cl_2 -S system shows only two well defined solid compounds, S_2Cl_2 and SCL_4 . But we find it convenient, nevertheless, to give a value for the heat of formation of the hypothetical $\text{S}_2\text{Cl}_4(\text{liq.})$.

$\text{SO}_2\text{Cl}_2(\text{liq.})$. Thomsen¹⁵ discovered that solid iodine acted as a catalyst for the reaction, $\text{SO}_2\text{Cl}_2(\text{liq.}) + 2\text{H}_2\text{O}(\text{liq.}) = (\text{H}_2\text{SO}_4 + 2\text{HCl})(1000)$, and his calorimetric data yield for this reaction $Q = 62.8$. Ogier⁷ measured the heat of solution of liquid sulfuryl chloride in aqueous KOH to be 119.8. These data yield for $\text{SO}_2\text{Cl}_2(\text{liq.})$ $Q_f = 92.9$ and 93.1 , respectively.

$\text{SO}_2\text{Cl}_2(\text{g.})$. The data on the heat of vaporization of liquid sulfuryl chloride are: Trautz,⁶ -6.68 , from direct calorimetric measurement; Trautz, Baisch, and von Dechend,¹ -6.68 , from vapor pressure data; Ogier,⁷ -7.1 , from the difference in the heats of solution of the gas and the liquid. These data yield, for $\text{SO}_2\text{Cl}_2(\text{g.})$, $Q_f = 86.2$, 86.2 , and 85.8 , respectively. Trautz and von Dechend¹ computed, from equilibrium data for the reaction, $\text{SO}_2(\text{g.}) + \text{Cl}_2(\text{g.}) = \text{SO}_2\text{Cl}_2(\text{g.})$, $Q = 11.2$; whence, for $\text{SO}_2\text{Cl}_2(\text{g.})$, $Q_f = 82.1$. See also Heumann and Käcklin.¹

$\text{SOCl}_2(\text{liq.})$. Ogier^{6, 7} measured the heat of solution of liquid thionyl chloride in water.

$\text{SOCl}_2(\text{g.})$. Ogier^{6, 7} reported -6.5 for the heat of vaporization of the liquid; Ariei,³ from vapor pressure data, deduced the value -7.56 .

$\text{S}_2\text{O}_5\text{Cl}_2(\text{liq.})$. Ogier⁷ found, for the heat of solution of liquid pyrosulfuryl chloride in 6 KOH (18), $Q = 39.2$; whence, for $\text{S}_2\text{O}_5\text{Cl}_2(\text{liq.})$, $Q_f = 166.5$.

$\text{S}_2\text{O}_5\text{Cl}_2(\text{g.})$. Ogier⁷ reported -13.2 for the heat of vaporization. See also Grignard and Muret.¹

SO₃HCl (liq.). Ogier⁶ measured the heat of formation of liquid sulfonic chloride from solid SO₃ (which we have assumed to be the wool-like form) and gaseous HCl, and the heat of solution of liquid SO₃HCl in water. For these reactions, he found $Q = 14.3$ and 40.3 , respectively; whence we have computed, for SO₃HCl (liq.), $Q_f = 141.6$ and 143.0 , respectively.

S₂Br₂ (liq.). Ogier⁷ and Peterson⁵ reported for the reaction, $2S$ (c, rhombic) + Br₂ (liq.) = S₂Br₂ (liq.), $Q = 4.0$ and 3.6 , respectively. It seems probable that both values are low.

S_xI_y (solid). According to Ogier⁷ there is no heat effect on mixing sulfur and iodine.

SOBr₂ (liq.). Mayes and Partington¹ reported -10.40 for the heat of vaporization at 140° . There is some decomposition at the boiling point.

SF₆ (g). Yost and Claussen¹ reported $Q_f = 262.0$.

SF₆ (c). The data on the heat of sublimation are: Klemm and Henkel,¹ -5.57 ; Yost and Claussen,¹ -5.64 ^{-63,8}.

SF₆ (liq.). The data on the heat of fusion are: Klemm and Henkel,¹ -1.1 ; Yost and Claussen,¹ -1.39 ^{-50,8}.

SELENIUM

Se (solid). The stable form of selenium is the gray metallic hexagonal Se (c, I). There are also the red monoclinic form, Se (c, III), the intermediate black monoclinic form, Se (c, II), and the vitreous form, which latter is apparently identical with precipitated selenium. Briegleb¹ gave a summary of the thermal properties of the various forms of solid selenium. Mondain-Monval^{1, 5} measured the heats of transition directly, finding: Se (vitreous) = Se (c, I), $Q^{125} = 1.08$; Se (c, III) = Se (c, I), $Q^{150} = 0.18$. Fabre,² from data on the difference in the heats of solution of the various forms of selenium in bromine, reported: Se (vitreous) = Se (c, I), $Q = 2.79$; Se (vitreous) = Se (amorphous), $Q = 0$. Peterson,⁵ from data on the differences in the heats of their reaction with chlorine, gave: Se (c, III) = Se (c, I), $Q = 0.70$; Se (vitreous) = Se (c, I), $Q = 1.05$. There are no thermal data on Se (c, II).

Se (liq.). From data on the vapor pressures of Se (c, II) and Se (liq.) reported by Dodd,¹ Le Chatelier,⁹ and Preuner and Brockmoller,¹ we have computed the heat of fusion to be -3.91 , if the vapor is assumed to be Se₈, and -2.9 , if the vapor is Se₆. From Mondain-Monval's^{1, 5} values at 125° , we have computed $F = -1.6$ at the melting point, 220° . This value agrees best with the assumption that the vapor has the composition Se₈ at the melting point.

Se₂ (g), Se₆ (g), Se₈ (g). From the vapor pressure data of Dodd,¹ we have computed for Se₈ (g), $Q_f = -34.8$, assuming that at the melting point of selenium its vapor is mostly Se₈. By analogy with sulfur we have computed, for Se₆ (g), $Q_f = -36$. Preuner and Brockmoller¹ gave -56 for the heat of the reaction Se_6 (g) = 3 Se₂ (g), whence, for Se₂ (g),

$Q_f = -30.7$. This was computed from equilibrium values calculated from their vapor density data. Similar data were given by Biltz⁷ and Deville and Troost.⁴ Preuner and Brockmüller¹ and Bodenstein³ estimated, from equilibrium data on the reaction, $\text{H}_2\text{Se (g)} = \text{H}_2\text{(g)} + \frac{1}{2}\text{Se}_2\text{(g)}$, $Q = -22.5$, whence, anticipating the value for $\text{H}_2\text{Se (g)}$, we have computed, for $\text{Se}_2\text{(g)}$, $Q_f = -29.5$.

Se (g). By analogy with O_2 and S_2 , we have estimated the energy of dissociation of Se_2 to be -92 , which value is in agreement with that estimated by von Wartenberg³ from vapor density data.

The values of the energy states of gaseous monatomic selenium are taken from McLennan and Crawford.¹ Gibbs and Ruddy¹ reported a value for the ionization potential. The spectra of $\text{Se}^+\text{(g)}$ have not been analyzed, but the higher spectra are discussed by Rao⁶ and Sawyer and Humphreys.¹ See also Bacher and Goudsmit.¹

Se⁻ (aq.). The values for aqueous selenide ion are obtained from those for $\text{Li}_2\text{Se (aq.)}$, $\text{Na}_2\text{Se (aq.)}$, $\text{K}_2\text{Se (aq.)}$. $\text{Li}^+\text{(aq.)}$, $\text{Na}^+\text{(aq.)}$, and $\text{K}^+\text{(aq.)}$

SeO₂ (aq.). Thomsen¹⁵ measured the heats of the following reactions: $\text{Se (vitreous)} + \frac{1}{2}\text{Cl}_2\text{(g)} = \frac{1}{2}\text{Se}_2\text{Cl}_2\text{(liq.)}$, $\frac{1}{2}\text{Se}_2\text{Cl}_2\text{(liq.)} + \frac{3}{2}\text{Cl}_2\text{(g)} = \text{SeCl}_4\text{(liq.)}$, and $\text{SeCl}_4\text{(liq.)} + 2\text{H}_2\text{O (liq.)} = (\text{SeO}_2 + 4\text{HCl})\text{(aq.)}$. For these reactions, the data of Thomsen¹⁵ yield $Q = 11.26$, 35.08 , and 30.37 , respectively. Addition of the three reactions yields for $\text{Se (vitreous)} + 2\text{Cl}_2\text{(g)} + 2\text{H}_2\text{O (liq.)} = (\text{SeO}_2 + 4\text{HCl})\text{(aq.)}$, $Q = 76.71$; whence, for $\text{SeO}_2\text{(aq.)}$, $Q_f = 55.43$. Thomsen¹⁵ also measured the heat of the reaction $\text{SeO}_2\text{(aq.)} + 2\text{HCl (aq.)} + \text{NaHS (aq.)} = \text{NaCl (aq.)} + 2\text{H}_2\text{O (liq.)} + \text{S (solid, ppt.)} + \text{Se (solid, ppt.)}$. His data yield, for this reaction, $Q = 73.40$; whence, for $\text{SeO}_2\text{(aq.)}$, $Q_f = 55.64$.

SeO₂ (c). For the heat of solution of $\text{SeO}_2\text{(c)}$ in water, Thomsen¹⁵ found $S = -0.92_{200}$ and Jannek and Meyer,¹ $S = -0.94_{100}$. These data yield, for $\text{SeO}_2\text{(c)}$, $Q_f = 54.50$. Mixer¹⁰ measured in a bomb calorimeter the heats of the reactions, $3\text{Na}_2\text{O}_2\text{(c)} + \text{Se (c, III)} = \text{Na}_2\text{SeO}_4\text{(c)} + 2\text{Na}_2\text{O (c)}$ and $\text{SeO}_2\text{(c)} + \text{Na}_2\text{O}_2\text{(c)} = \text{Na}_2\text{SeO}_4\text{(c)}$. He found, for these reactions, $Q = 95.90$ and 71.20 , respectively, and the difference gives for, $\text{Se (c, III)} + 2\text{Na}_2\text{O}_2\text{(c)} = \text{SeO}_2\text{(c)} + 2\text{Na}_2\text{O (c)}$, $Q = 24.70$; whence, for $\text{SeO}_2\text{(c)}$, $Q_f = 65.1$. This high value is due, as Mixer reported, to the fact that the second reaction did not go to completion.

H₂SeO₃ (c). Jannek and Meyer¹ measured the heat of solution in water. See also the vapor pressure data of Manchot.¹

SeO₃⁻ (aq.). This value is computed from those for $\text{Na}_2\text{SeO}_3\text{(aq.)}$ and $\text{Na}^+(\infty)$.

HSeO₃⁻ (aq.). This value is computed from those for $\text{NaHSeO}_3\text{(aq.)}$ and $\text{Na}^+(\infty)$.

H₂Se (g). Fabre¹ measured the heats of the reactions, $\text{H}_2\text{Se (g)} + 2\text{FeCl}_3\text{(aq.)} = \text{Se (solid, ppt.)} + (2\text{FeCl}_2 + 2\text{HCl})\text{(aq.)}$ and $2\text{H}_2\text{Se (g)} + \text{SeO}_2\text{(aq.)} = 3\text{Se (solid, ppt.)} + 2\text{H}_2\text{O (liq.)}$. His data yield $Q = 42.2$ and 120.1 , respectively; whence we have computed, for $\text{H}_2\text{Se (g)}$, Q_f

= -18.5 and -19.8, respectively. Rolla's¹ data on the temperature coefficient of the equilibrium constant for the reaction, $\text{H}_2\text{Se (g)} + \text{I}_2 \text{ (c)} = 2 \text{ HI (g)} + \text{Se (solid)}$, yield, for $\text{H}_2\text{Se (g)}$, $Q_f = -16.9$. Pelabon's¹ data on the equilibrium $\text{H}_2\text{Se (g)} = \text{H}_2 \text{ (g)} + \text{Se (liq.)}$ yield, for $\text{H}_2\text{Se (g)}$, $Q_f = -19.0$.

$\text{H}_2\text{Se (aq.)}$. From data on the temperature coefficient of the solubility of H_2Se in water, McAmis and Felsing¹ computed the heat of solution of gaseous hydrogen selenide to be 2.43. From the similar but less accurate data of de Forcrand and Fonzes-Diacon,^{1,2} we have computed $S = 3.2$. Fabre¹ measured the heats of reaction of aqueous H_2Se and gaseous H_2Se with aqueous NaOH and aqueous KOH , respectively. Proper differences of these reactions would give values for the heat of solution of H_2Se in water; but, unfortunately, the data when so treated yield $S = 9.36$ and 9.77 , respectively,—values in sharp disagreement with the preceding ones. The discrepancy may be explained by assuming that Fabre erred in recording his data on the neutralizations with gaseous H_2Se . Fabre's value for the neutralization of aqueous H_2Se is in accord with similar data on the homologous $\text{H}_2\text{S (aq.)}$. If we assume that to Fabre's¹ data on the reaction between gaseous H_2Se and aqueous NaOH and KOH respectively the factor $\frac{1}{2}$ should be applied, then one obtains, for $\text{H}_2\text{Se (g)}$, $S = 1.00$ and 1.31 , respectively.

$\text{HSe}^- \text{ (aq.)}$. This value is obtained from those for aqueous NaHSe and KHSe .

$\text{H}_2\text{SeO}_4 \text{ (aq.)}$. Thomsen¹⁵ measured the heat of the reaction, $\text{SeO}_2 \text{ (500)} + \text{HClO (700)} + \text{H}_2\text{O (liq.)} = (\text{H}_2\text{SeO}_4 + \text{HCl}) \text{ (1200)}$, and his data yield $Q = 29.78$; whence, neglecting the heat of mixing, we have computed, for $\text{H}_2\text{SeO}_4 \text{ (1200)}$, $Q_f = 143.8$. Fabre's¹ data on the heat of the reaction, $\text{Se (c)} + 3 \text{ Br}_2 \text{ (liq.)} + 4 \text{ H}_2\text{O (liq.)} = (\text{H}_2\text{SeO}_4 + 6 \text{ HBr}) \text{ (aq.)}$, yield $Q = 42.2$; whence, for $\text{H}_2\text{SeO}_4 \text{ (aq.)}$, $Q_f = 144.5$. We have estimated the heat of dilution of aqueous selenic acid to be the same as that for sulfuric acid.

$\text{H}_2\text{SeO}_4 \text{ (liq.)}$. Metzner^{1,2} measured the heat of solution in water.

$\text{H}_2\text{SeO}_4 \text{ (c.)}$. Metzner^{1,2} measured the heat of solution in water.

$\text{H}_2\text{SeO}_4 \cdot \text{H}_2\text{O (liq.)}$. Metzner^{1,2} measured the heat of solution in water.

$\text{H}_2\text{SeO}_4 \cdot \text{H}_2\text{O (c.)}$. Metzner^{1,2} measured the heat of solution in water.

$\text{SeO}_4^{--} \text{ (aq.)}$. From the values for $\text{Na}_2\text{SeO}_4 \text{ (}\infty\text{)}$, $\text{Na}^+ \text{ (}\infty\text{)}$, $\text{K}_2\text{SeO}_4 \text{ (}\infty\text{)}$, and $\text{K}^+ \text{ (}\infty\text{)}$, we have computed that for $\text{SeO}_4^{--} \text{ (}\infty\text{)}$.

$\text{HSeO}_4^- \text{ (aq.)}$. We have computed this value from those for $\text{NaHSeO}_4 \text{ (aq.)}$, $\text{Na}^+ \text{ (}\infty\text{)}$, $\text{KHSeO}_4 \text{ (aq.)}$, and $\text{K}^+ \text{ (}\infty\text{)}$.

$\text{SeF}_6 \text{ (g.)}$. Yost and Claussen¹ reported $Q_f = 246.0$.

$\text{SeF}_6 \text{ (c.)}$. Klemm and Henkel¹ reported -6.72^{45} for the heat of sublimation; Yost and Claussen¹ reported $-6.60^{46,6}$.

$\text{SeF}_6 \text{ (liq.)}$. Klemm and Henkel¹ gave -1.1 for the heat of fusion of the solid; Yost and Claussen¹ reported $-2.0^{34,6}$.

Se₂Cl₂ (liq.). Thomsen¹⁵ and Peterson⁵ measured the heat of formation of liquid Se₂Cl₂ from vitreous selenium and gaseous chlorine. Their data yield $Q = 22.13$ and 21 , respectively.

SeCl₄ (c). The data of Thomsen¹⁵ on the reaction, Se₂Cl₂ (liq.) + 3 Cl₂ (g) = 2 SeCl₄ (c), yield $Q = 70.10$; whence, for SeCl₄ (c), $Q_f = 46.12$.

SeCl₂ (g). From data on the dissociation pressure of solid SeCl₄, and on the vapor density of the dissociation products, Yost and Kircher¹ calculated, for SeCl₄ (c) = SeCl₂ (g) + Cl₂ (g), $Q^{160} = -35.38$; whence, for SeCl₂ (g), $Q_f = 10.0$.

SeO₂ · SO₃ (c). Metzner^{1, 2} measured the heat of solution in water.

TELLURIUM

Te (c, II). Standard state.

Te (c, I). Umino² measured the heat of transition.

Te (solid, amorphous). Damiens¹ found the heat of solution, in strong bromine water, of the quenched melt of tellurium and the amorphous or chemically precipitated tellurium to be zero and 2.7 , respectively, greater than that of Te (c, II).

Te (liq.). Umino² measured the heat of fusion of Te (c, I).

Te₂ (g). At temperatures above the boiling point, tellurium vapor is diatomic. The vapor pressure data of Doolan and Partington,¹ which were obtained at lower temperatures, do not extrapolate to the known boiling point, and indicate higher association of the vapor. See also Deville and Troost.⁴ These data lead to the values $V = -28.0^{600}$ and -20.0^{1500} , whence, for Te₂ (g), $Q_f = -24$. This value is not very certain.

Te (g). von Wartenberg³ estimated, from vapor density measurements at 2200° and the Nernst equation, that the heat of dissociation of Te₂ (g) into 2 Te (g) is -87.0^{2200} . See also Biltz⁷ and Deville and Troost.^{1, 4}

McLennan and Crawford¹ gave data on the energy levels of monatomic gaseous tellurium. See also Bacher and Goudsmit.¹

TeCl₄ (c). Thomsen's¹⁵ data on the reaction, Te (c, II) + 2 Cl₂ (g) = TeCl₄ (c), yield, for the latter, $Q_f = 77.4$.

TeO₂ (aq. HCl). Thomsen¹⁵ found the heat of solution of TeCl₄ (c) in water to be 20.37 .

H₂TeO₃ (c). Thomsen¹⁵ found the heat of solution of this compound in water to be zero.

TeO₂ (c). Thomsen¹⁵ measured the heat of the reaction, (TeO₂ + 4 HCl) (aq.) + 2 SnCl₂ (aq.) = Te (amorp., ppt.) + 2 SnCl₄ (aq.) + 2 H₂O (liq.), and his data yield, for TeO₂ (c), $Q_f = 77.6$. Schuhmann² measured the electromotive force at various temperatures of the cell in which the reaction was Te (c, II) + 2 H₂O (liq.) = TeO₂ (c) + 2 H₂ (g), and his data yield, for TeO₂ (c, II), $Q_f = 77.58$. Mixer's¹⁰ data on the reactions of sodium peroxide with Te and TeO₂, respectively, lead to a value of 88.7 for the heat of formation of TeO₂ (c).

H₂TeO₄ (aq.). Thomsen¹⁵ measured the heat of oxidation of aqueous TeO₂ with potassium permanganate, and his data yield, for H₂TeO₄ (400), $Q_f = 165.3$. Berthelot and Fabre¹ oxidized solid tellurium with liquid bromine in the presence of water, $\text{Te (c)} + 3 \text{Br}_2 \text{ (liq.)} + 4 \text{H}_2\text{O (liq.)} = (\text{H}_2\text{TeO}_4 + 6 \text{HBr}) \text{ (aq.)}$, and their data yield, for H₂TeO₄ (aq.), $Q_f = 169.3$.

H₂TeO₄ · 2 H₂O (c). Metzner¹ measured the heat of solution in water.

SO₂ · 2 TeO₂ (c). Metzner¹ measured the heat of solution of this compound in aqueous KOH.

H₂Te (g). The data of Berthelot and Fabre¹ on the reaction, $\text{H}_2\text{Te (g)} + 2 \text{FeCl}_3 \text{ (aq.)} = \text{Te (ppt.)} + (2 \text{FeCl}_2 + 2 \text{HCl}) \text{ (aq.)}$ yield, for H₂Te (g), $Q_f = -34.2$.

TeBr₄ (c). Beck¹ found for the reaction of the solid tetrabromide with aqueous sodium acetate, $Q = 7.05$; whence, for TeBr₄ (c), $Q_f = 49.3$.

TeF₆ (g). Yost and Claussen¹ reported $Q_f = 315.0$.

TeF₆ (c). Klemm and Henkel¹ gave for the heat of sublimation, -5.13^{-28} ; Yost and Claussen¹ reported $-6.74^{-88,9}$.

TeF₆ (liq.). Klemm and Henkel¹ gave for the heat of fusion, -1.6 ; Yost and Claussen¹ estimated -1.9 .

POLONIUM

Po (c). Standard state.

NITROGEN

N₂ (g). The standard state is taken as the equilibrium gas at 18°. The values for the energy states of gaseous diatomic nitrogen are from Sponer,^{1,3} Birge and Hopfield,^{1,4} and Mulliken.^{3,6} See also Jevons.¹ Data on the energy of ionization of N₂ (g) were reported by Sponer,³ Smyth,³ Turner and Samson,¹ and Tate, Smith, and Vaughan,¹ the value of the last named being 15.65 ± 0.02 volt-electrons.

N (g). The value for the energy of dissociation of normal gaseous N₂ into normal gaseous N atoms is taken from Herzberg and Sponer,¹ Kaplan,⁵ and Lozier.³ Herzberg and Sponer¹ reported the value 7.34 ± 0.02 volt-electrons. See also van der Ziel,¹ Birge,^{1,3,8,10} Birge and Hopfield,^{1,4} Turner and Samson,¹ Lozier,¹ Hogness and Lunn,¹ Brandt,¹ Duncan,¹ Kneser,¹ Mohler and Foote,¹ and Grimm and Eucken.¹

The energies of ionization of monatomic nitrogen to various stages are taken from the following works: Hopfield⁴ and Compton and Boyce,¹ first step; Bowen² and Fowler and Freeman,¹ second step; Bowen,² Millikan and Bowen,^{3,4} and Freeman,¹ third step; Edlen,¹ fourth step; Edlen and Ericson,⁵ fifth step. The values for the sixth and seventh steps are taken from the calculations of Laporte and Young.¹

N₂ (liq.). From a review of the data of Alt,¹ Dana,¹ Eucken,^{2,3} Keesom and Houlhoff,¹ Millar and Sullivan,¹ Burnett,¹ Shearer,¹ Rodebush, Andrews, and Taylor,¹ and Mathias, Crommelin, and Onnes,⁴ Wiebe and Brevoort¹ deduced $V = -1.335$ at the boiling point, -195.7° . Vapor

pressure data were reported by Crommelin,⁴ Cath,¹ Mathias, Onnes, and Crommelin,¹ Onnes, Dorsman, and Holst,¹ Wroblewsky,⁴ Baly,¹ Fischer and Alt,¹ Holst and Hamburger,^{1, 2} Henning and Heuse,¹ Olschewsky,^{1, 3, 5, 10, 11} Porter and Perry,¹ and von Siemans.¹

N₂ (c). Eucken^{2, 3} measured the heat of fusion of N₂ (c, I) and the heat of transition of N₂ (c, II) to N₂ (c, I). See also Estreicher.¹

NH (g). Bates¹ determined, from spectroscopic data, the energy of dissociation of NH into normal atoms, and the energy of the first electronic state.

NH₃ (g). Thomsen¹⁵ and Berthelot²¹ measured the heat of combustion of gaseous ammonia, and their data yield, for NH₃ (g), $Q_f = 11.7$ and 11.2 , respectively. Haber,⁴ Haber, Tamaru, and Oeholm,¹ Haber and Tamaru,¹ and Tamaru¹ measured the heat of the dissociation, NH₃ (g) $= \frac{1}{2}$ N₂ (g) $+ \frac{3}{2}$ H₂ (g), at various temperatures. Lewis and Randall⁵ reviewed these data, and their equation yields, for NH₃ (g), $Q_f = 10.97$. Equilibrium data on the synthesis of gaseous ammonia from nitrogen and hydrogen were obtained by Haber,^{3, 4, 5} Haber, Tamaru, and Ponnay,¹ Haber and Maschke,¹ Haber and Greenwood,¹ Haber, Tamaru, and Oeholm,¹ Haber and Moser,¹ Haber and Le Rossignol,^{1, 2, 3, 4} Claude,¹ Lebeau and Jost,^{1, 2} Nernst,⁴ Larson,¹ and Larson and Dodge.¹ See also Haber and van Oordt,^{1, 2, 3} Gillespie^{1, 4} and Gillespie and Beattie^{1, 2, 3} critically reviewed the recent accurate data of Larson¹ and Larson and Dodge,¹ and, after making corrections for the deviations from the ideal gas laws, deduced, for NH₃ (g), $Q_f = 10.74$.

NH₃ (liq.). The most accurate value for the heat of vaporization of liquid ammonia is that of Osborne and Van Dusen,¹ who found $V = -5.56$ at the normal boiling point. From this value, we have computed $V = -5.07$ at 18°. Other data on the heat of vaporization of ammonia are given by Estreicher and Schneer,¹ Holst,^{1, 3} de Forcrand and Massol,¹ Henning,¹ Regnault,³ Strombeck,¹ Franklin and Kraus,¹ Brill,¹ Eucken and Karwat,¹ and Donath.¹

NH₃ (c). By direct calorimetric measurement, Eucken and Karwat¹ and Eucken and Donath¹ found $F = -1.43$ and -1.420 , respectively, at the freezing point, -77.6° . From the difference in the heats of solution of the solid and the liquid, Massol² (see de Forcrand and Massol¹) found the heat of fusion of solid ammonia to be -1.84 at -75° . The values of Eucken and co-workers are in accord with those calculated from the differences in the variation, with temperature, of the logarithm of the vapor pressures of the solid and liquid, respectively, data on which are given for the solid, by Cragoe, Meyers, and Taylor,¹ Karwat,¹ McKelvy and Taylor,¹ Smits and Postma,¹ Briner,¹ Burrell and Robertson,^{1, 3} and Mundel,¹ and, for the liquid, by Cragoe, Meyers, and Taylor,¹ Henning and Stock,¹ and others. See also the calculations by Karwat¹ and Rideal.¹

NH₃ (aq.). The data on the heat of solution of gaseous ammonia in water yield the following values: Thomsen,^{3, 15} 8.47_{200} ; Berthelot,²¹ 8.82^{10} , 8.2^{100} ; Favre and Silbermann,³ 8.75^{15} ; Baud and Gay,¹ 8.55_{200}^{13} ;

Wrevski and Savaritski,¹ 8.35₂₀₀. The data of Ramstetter and Hantke¹ show an incorrect trend. The data on the heat of dilution of aqueous ammonia given by Thomsen,¹⁵ Baud and Gay,¹ and Wrevski and Savaritski¹ were reviewed by Bichowsky.²

NH₄F (aq.). Guntz¹ found $N=15.2$.

NH₄F (c). Guntz¹ quoted a value for the heat of solution obtained by Favre, whose report we have been unable to find. Simon, Simson, and Ruhemann¹ found no transitions in solid ammonium fluoride.

NH₄Cl (aq.). The data on the heat of neutralization of aqueous ammonia with aqueous hydrochloric acid yield the following values for N_{200} : Hess,⁶ —; Berthelot,⁴ —; Favre and Silbermann,³ 13.5; Andrews,^{1, 2, 11} 12.96; Thomsen,¹⁵ 12.30; Biltz and Messerknecht,² 12.30. Data on the heat of dilution of aqueous ammonium chloride were reported by Pratt,¹ Thomsen,¹⁵ Magie,¹ Stackelberg,¹ Winkelmann,¹ and Lehtonen.¹ We have extrapolated these data to infinite dilution.

NH₄⁺ (aq.). From the values for NH₄Cl (∞) and Cl⁻ (∞), and NH₄NO₃ (∞) and NO₃⁻ (∞), we have computed, for NH₄⁺ (∞), $Q_f=31.455$ and 31.47, respectively.

NH₄Cl (c, II). The existing data yield the following values for the heat of solution of ammonium chloride: Anderson and Noyes,¹ -3.86₂₀₀; Berthelot,⁷ -4.0; Favre and Silbermann,³ -3.4; Mondain-Monval,³ -3.84¹⁹; Winkelmann,¹ -3.92₂₀₀; Colson,⁵ -3.95₂₀₀; Stackelberg,¹ -3.93₁₅₀; Van Deventer and van der Stadt,¹ -3.88₂₀₀; Thomsen,¹⁵ -3.92₂₀₀. Lehtonen¹ measured the heat of solution at 0°. Raabe¹ measured the heat of the reaction, NH₃ (g) + HCl (g) = NH₄Cl (c), finding $Q=44.46$; whence, for NH₄Cl (c), $Q_f=77.4$. Some error must exist in his data. Bronsted⁸ measured the heat of the reaction $\frac{1}{2}$ H₂ (g) + NH₃ (in sat'd. aq. NH₄Cl) + HgCl (c) = Hg (liq.) + NH₄Cl (c, II), finding $Q=70.60$; but we can not use these data to obtain a value for the heat of formation of solid ammonium chloride without a value for the heat of solution of gaseous ammonia in saturated aqueous ammonium chloride.

NH₄Cl (c, I). For the transition at 184°, Scheffer^{3, 4} found -1.03; Bridgman,⁷ -0.88; Klinkhardt,¹ -0.97.

NH₄Cl (c, III). Simon³ found $T=-0.356_{-11}^{-31}$. See also Ewald.¹

NH₄Cl (g). Gutmann,¹ Johnston,⁴ Neuberger,¹ Pullinger and Gardner,¹ Ramsay and Young,^{1, 4} Deville and Troost,¹ Smith and Lombard,^{1, 2} and Rodebush and Michalek¹ obtained data on the dissociation of gaseous ammonium chloride. These data yield for the reaction NH₃ (g) + HCl (g) = NH₄Cl (g), $Q=9.4$; whence, for NH₄Cl (g), $Q_f=42.4$. See also Wegscheider¹ and Smith and Lombard.¹ Because they took special care to reach equilibrium, we have selected the values of Smith and Calvert^{1, 2} and Smith and Lombard^{1, 2} for the heat of sublimation of solid ammonium chloride, in preference to the values of Braune and Knoke,¹ Rassow,¹ Scheffer,¹ Johnson,⁵ Horstman,¹ Ramsay and Young,^{1, 4} Smith and Menzies,¹ and Wegscheider.^{1, 2} See also Smits¹ and Smits and DeLange.¹

NH₄Br₃ (c). The data of Hüttig and Schliessmann¹ on the dissociation pressure of solid NH₄Br₃ at various temperatures, yield $D = -12.8$, which value seems high. See also Ephraim.³

NH₄I (aq.). The value of Q_f for this substance is obtained from those for aqueous ammonium and iodide ions.

NH₄I (c, I). The existing data yield the following values for the heat of solution: Thomsen,¹⁵ -3.56_{200} ; Varet,² -3.5 .

NH₄⁺ (g). Grimm² showed that the heat of formation of this substance can be calculated by the method of lattice energies. Using the values given by Sherman¹ for the lattice energies of NH₄F, NH₄Cl, NH₄Br, and NH₄I, and our values for the other thermal quantities needed, we have computed, for NH₄⁺ (g), $Q_f = 0.0, -17.3, -21.2$ and -42.2 , respectively. We have selected -20 as the mean of these very discordant results.

NH₄Br (aq.). The heat of formation of aqueous ammonium bromide is computed from the values for NH₄⁺ (aq.) and Br⁻ (aq.).

NH₄Br (c, II). The data on the heat of solution yield the following values: Thomsen,¹⁵ -4.45_{200} ; Andre,¹ -4.87^5 .

NH₄Br (c, I). Bridgman⁷ determined the heat of transition.

NH₄I (c, II). Bridgman reported $T = -0.701_{-1}^{-18}$. See also Simon, Simson, and Ruhemann.¹

NH₄I₃ (c). Foote and Bradley¹ studied the equilibrium, NH₄I₃ (c) = NH₄I (c) + I₂ (g).

NH₄ClO₄ (aq.). Berthelot⁷⁹ measured the heat of neutralization.

NH₄ClO₄ (c). Berthelot⁷⁹ measured the heat of solution.

(NH₄)₂S (aq.). Thomsen¹⁵ measured the heat of solution of gaseous H₂S in aqueous ammonia to form aqueous (NH₄)₂S to be 11.10; and Berthelot¹⁴ measured the heat of neutralization of aqueous H₂S with aqueous ammonia to form aqueous (NH₄)₂S to be 6.2¹⁵. These data yield for (NH₄)₂S (aq.), $Q_f = 55.0$ and 54.7 , respectively.

NH₄HS (aq.). Thomsen¹⁵ found $Q = 0.15$ for the heat of mixing aqueous NH₃ with aqueous NH₄HS.

NH₄HS (c). Berthelot¹⁴ measured the heat of solution. Vapor pressure data for solid ammonium bisulfide were given by Salet,¹ Isambert,^{1, 7, 9} Briner,¹ Magnusson,¹ and Walker and Lumsden.¹ Randall and White² reviewed these data and gave for the reaction, NH₄HS (c) = NH₃ (g) + H₂S (g), $Q = -22.24$, whence, for NH₄HS (c), $Q_f = 38.5$.

NS (c). Berthelot and Vielle³ determined the heat of decomposition to be -31.9 .

NSe (c). Berthelot and Vielle³ determined the heat of decomposition to be -42.3 .

(NH₄)₂S_n (aq.). Sabatier¹ measured the heats of reaction with aqueous iodine of (NH₄)₂S₄ (aq.), (NH₄)₂S₅ (aq.), and (NH₄)₂S₈ (aq.), respectively.

(NH₄)₂S_n (c). Sabatier¹ measured the heats of solution of (NH₄)₂S₄ (c), (NH₄)₂S₅ (c), and (NH₄)₂S₈ (c).

$(\text{NH}_4)_2\text{SO}_3$ (aq.). de Forcrand^{5, 15} measured the heat of neutralization of SO_2 (aq.) with 2NH_3 (aq.), and the heat of mixing NH_3 (aq.) with NH_4HSO_3 (aq.). His data yield, for $(\text{NH}_4)_2\text{SO}_3$ (aq.), $Q_f = 210.8$ and 210.4 , respectively.

$(\text{NH}_4)_2\text{SO}_3$ (c). de Forcrand^{5, 15} measured the heat of solution.

$(\text{NH}_4)_2\text{SO}_3 \cdot \text{H}_2\text{O}$ (c). For the heat of solution, de Forcrand^{5, 15} found -5.4^8 and Hartog¹ -4.3 . de Forcrand's sample was not pure.

NH_4HSO_3 (aq.). de Forcrand^{5, 15} measured the heat of mixing SO_2 (aq.) with NH_3 (aq.), finding $N = 14.78^9$, whence, for NH_4HSO_3 (aq.), $Q_f = 180.85$.

NH_4HSO_3 (c). de Forcrand^{5, 15} measured the heat of solution.

$(\text{NH}_4)_2\text{S}_2\text{O}_5$ (aq.). The value for this substance is taken equal to that for $2\text{NH}_4\text{HSO}_3$ (aq.) minus that for H_2O (liq.).

$(\text{NH}_4)_2\text{SO}_4$ (aq.). The existing data yield the following values for the heat of neutralization of aqueous ammonia with aqueous sulfuric acid: Thomsen,¹⁵ 28.96_{400} ; Berthelot,⁴ 29.0_{400}^{20} ; Favre,⁸ 29.8 ; Bouzat,¹ 29.05_{400}^{42} ; Hess,^{1, 2, 3, 4} —; Andrews,^{1, 2, 10} 29.4 ; Favre and Silbermann,³ 29.4 . See also Roth.⁵ The heat of dilution of aqueous ammonium sulfate was measured by Thomsen.¹⁵ See also Roth.⁵

$(\text{NH}_4)_2\text{SO}_4$ (c). The existing data on the heat of solution yield the following values: Thomsen,¹⁵ -2.38_{400} ; Favre,⁸ -2.0 ; Berthelot,⁴ -2.6 ; Van Deventer and van der Stadt,¹ -2.32_{200} ; Roth,⁵ -2.03_{200} . See also Favre and Silbermann.³

NH_4HSO_4 (aq.). Thomsen¹⁵ and Berthelot⁴ obtained the same value, -1.41 , for the heat of the reaction, H_2SO_4 (200) + $(\text{NH}_4)_2\text{SO}_4$ (200) = $2\text{NH}_4\text{HSO}_4$ (200).

NH_4HSO_4 (c). Thomsen¹⁵ measured the heat of solution.

$(\text{NH}_4)_2\text{S}_2\text{O}_8$ (aq.). The value for this substance is obtained from those for the ions.

$(\text{NH}_4)_2\text{S}_2\text{O}_8$ (c). Berthelot¹⁰⁷ measured the heat of solution.

NH_4HSe (aq.). Fabre¹ found, for NH_3 (aq.) + H_2Se (aq.), $N = 6.2$.

$(\text{NH}_4)_2\text{Se}$ (aq.). The value for this substance is obtained from those for the ions.

NO (g). Berthelot^{29, 58} measured the heats of the reactions, $\frac{1}{2}\text{C}_2\text{N}_2$ (g) + O_2 (g) = CO_2 (g) + $\frac{1}{2}\text{N}_2$ (g) and $\frac{1}{2}\text{C}_2\text{N}_2$ (g) + 2NO (g) = CO_2 (g) + $\frac{3}{2}\text{N}_2$ (g). The difference gives the heat of the reaction, O_2 (g) + N_2 (g) = 2NO (g), and Berthelot's data yield, for NO (g), $Q_f = -21.85$. Berthelot's data on similar experiments with ethylene instead of cyanogen yield, for NO (g), $Q_f = -21.6$. See also Favre and Silbermann² and Dulong.² The high temperature equilibrium data on the reaction between N_2 and O_2 to form NO , obtained by Nernst,^{2, 3} Finckh,¹ Jellinek,¹ Grau and Russ,¹ Haber and Koenig,^{1, 2} and Nuranen,¹ were reviewed by Lewis and Randall⁵ and Randall and White,¹ and shown to be consistent with the heat of formation value deduced from Berthelot's data.

NO (liq.). By direct calorimetric measurement, Johnston and Giauque¹ found $V = -3.293^{-151.7}$. Similar data were obtained earlier by

Eucken and Karwat.¹ The vapor pressure data of Goldschmidt,² Henglein and Kruger,¹ and Johnston and Giauque¹ are in accord with the latter's direct calorimetric value.

NO (c). Johnston and Giauque¹ found $F = -0.550$ -^{163.6}, which value is in accord with the values of the heat of sublimation obtained from the vapor pressure data of Johnston and Giauque,¹ Mundel,¹ Henglein and Kruger,¹ and Goldschmidt.²

The values of the energy states of the NO molecule are from Mulliken.⁶ See also Jevons.¹

N₂O (g). The heat of combustion of N₂O with H₂, or with CO, was measured by Favre,^{1a} Berthelot,⁵⁸ Thomsen,¹⁵ Sutton,¹ Awbery and Griffiths,² and Fenning and Cotton.¹ Sutton¹ measured in a bomb calorimeter the heat of reaction of N₂O with H₂, and his data yield, for N₂O (g), $Q_f = 20.4 \pm 0.3$. Awbery and Griffiths,² with a constant pressure flame calorimeter, and Fenning and Cotton,¹ with a bomb calorimeter, measured the heats of the reactions, $\text{CO (g)} + \frac{1}{2} \text{O}_2 \text{ (g)} = \text{CO}_2 \text{ (g)}$ and $\text{N}_2\text{O (g)} + \text{CO (g)} = \text{CO}_2 \text{ (g)} + \text{N}_2 \text{ (g)}$, the difference of which gives the heat of formation of nitrous oxide. Their data yield, for N₂O (g), $Q_f = -19.52 \pm 0.22$ and -19.74 ± 0.07 , respectively.

N₂O (liq.), N₂O(c). The heats of vaporization and fusion are evaluated from the data of Eucken and Donath,¹ Cailletet and Mathias,¹ Young,² Burrell and Robertson,³ Bergstrom,^{2, 3} Regnault,⁷ Cardoso and Arni,¹ Grunmach,¹ Villard,^{1, 3, 9} Kuenen,¹ Ramsay and Shield,¹ Pictet,¹ Hunter,¹ Dewar,² Faraday,^{1, 3} Britton,¹ Cailletet and Colardeau,¹ Marshall and Ramsay,¹ Mathias,^{1, 2} and Mills.¹

N₂O (aq.). Villard^{1, 2, 3, 4, 9, 10} measured the heat of solution of the gas in water at 0°.

N₂O·6 H₂O (c). The equilibrium data of Tamman and Krige¹ and Villard^{1, 2, 3, 4, 9, 10} yield for the heat of decomposition of this hydrate (concerning whose composition there is some question) -15.0 per mole of gas. Villard's data yield 8.4 for the heat of formation of N₂O·6 H₂O (c) from aqueous N₂O and liquid H₂O.

NO₂ (g). Randall and White¹ reviewed the equilibrium data of Bodenstein,⁵ Colson,³ Schreber,¹ Russ,¹ Scheffer and Treub,¹ and Bodenstein and Katayama¹ on the reaction, $\text{NO (g)} + \frac{1}{2} \text{O}_2 \text{ (g)} = \text{NO}_2 \text{ (g)}$, and concluded that $Q = 13.57$; whence, for NO₂ (g), $Q_f = -8.03$.

N₂O₄ (g). Randall and White¹ reviewed the equilibrium data (obtained from vapor densities) of Mittasch, Kuss, and Schlueter,¹ Scheffer and Treub,² Wourtzell,¹ Schreber,¹ Bodenstein,⁵ Richardson,² and Deville and Troost³ on the reaction, $2 \text{NO}_2 \text{ (g)} = \text{N}_2\text{O}_4 \text{ (g)}$, and concluded that $Q = 13.00$. Bodenstein⁵ gave 13.88 ; Wourtzell,¹ 13.43 . Using the value 13.00 we have computed, for N₂O₄ (g), $Q_f = -3.06$. The data of Thomsen¹⁵ and Berthelot,²⁸ who each measured the heat of the reaction, $2 \text{NO (g)} + \text{O}_2 \text{ (g)} = \text{N}_2\text{O}_4 \text{ (g)}$, yield, for N₂O₄ (g), $Q_f = -4.06$ and -4.40 , respectively.

N₂O₄ (liq.). Berthelot and Ogier⁵ measured the heat of condensation

of gaseous N_2O_4 to be 8.6 at 25° . The vapor pressure data of Mittasch, Kuss, and Schlueter,¹ Scheffer and Treub,² Guye and Drouginine,¹ and Russ¹ yield -9.2 for the heat of vaporization of liquid N_2O_4 at 18° .

N_2O_4 (c). By direct measurement, Ramsay² found $F = -2.96^{10}$, while data on the freezing point lowering yield -3.10 . These values are in accord with the heat of sublimation calculated by Russ.¹ See also Egerton.¹

N_2O_3 (g). This unstable gas exists in equilibrium mixtures with NO and N_2O_4 . The equilibrium data of Abel and Prois¹ on the reactions, $2\text{NO}(\text{g}) + \text{N}_2\text{O}_4(\text{g}) = 2\text{N}_2\text{O}_3(\text{g})$ and $\text{NO}(\text{g}) + \text{NO}_2(\text{g}) = \text{N}_2\text{O}_3(\text{g})$, yield $Q = 5.6$ and 9.6 , respectively; whence, for N_2O_3 (g), $Q_f = -20.3$ and -20.0 .

N_2O_3 (liq.). The vapor pressure data of Guye and Drouginine¹ yield $V = -9.40^{20}$, which indicates partial dissociation of the vapor.

HNO_2 (aq.). Thomsen^{13, 15} measured the heat of solution in water of gaseous N_2O_4 and the heat of reaction of aqueous N_2O_4 with gaseous Cl_2 . If aqueous N_2O_4 is equivalent to an aqueous mixture of nitrous and nitric acids, then one may write $\text{N}_2\text{O}_4(\text{g}) + \text{H}_2\text{O}(\text{liq.}) = (\text{HNO}_2 + \text{HNO}_3)(\text{aq.})$, and $(\text{HNO}_2 + \text{HNO}_3)(\text{aq.}) + \text{H}_2\text{O}(\text{liq.}) + \text{Cl}_2(\text{g.}) = (2\text{HNO}_3 + 2\text{HCl})(\text{aq.})$. Neglecting the heats of mixing, and subtracting the second equation from the first, one obtains $\text{N}_2\text{O}_4(\text{g}) + 2\text{HCl}(\text{aq.}) = 2\text{HNO}_2(\text{aq.}) + \text{Cl}_2(\text{g.})$. Thomsen's data on these two reactions yield, for $\text{HNO}_2(\text{aq.})$, $Q_f = 31.4$. Klemenc and Hayek^{1, 2} obtained data on the equilibrium $3\text{HNO}_2(\text{aq.}) = \text{HNO}_3(\text{aq.}) + 2\text{NO}(\text{g}) + \text{H}_2\text{O}(\text{liq.})$, and computed $Q = -10.72$. Combination of this value with Thomsen's data on the reaction of gaseous Cl_2 with aqueous N_2O_4 (see above) yields, for HNO_2 (aq.) $Q_f = 28.45$.

Berthelot²⁸ measured the heat of the reaction between gaseous nitric oxide, oxygen, and aqueous barium hydroxide, and assumed that only nitrite was formed: $2\text{NO}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) + \text{Ba}(\text{OH})_2(\text{aq.}) = \text{Ba}(\text{NO}_2)_2(\text{aq.}) + \text{H}_2\text{O}(\text{liq.})$. Berthelot²⁸ also measured the heat of the reaction $\text{Ba}(\text{NO}_2)_2(\text{aq.}) + \text{H}_2\text{SO}_4(\text{aq.}) = 2\text{HNO}_2(\text{aq.}) + \text{BaSO}_4(\text{c.})$. Combination of these equations with our value for the heat of neutralization of aqueous $\text{Ba}(\text{OH})_2$ with aqueous sulfuric acid gives $2\text{NO}(\text{g}) + \frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{liq.}) = 2\text{HNO}_2(\text{aq.})$. And from these data, we have computed, for HNO_2 (aq.), $Q_f = 30.0$. Berthelot's²⁸ data on the reaction between gaseous chlorine and aqueous barium nitrite yield, for HNO_2 (aq.), $Q_f = 28.3$. Berthelot²⁸ measured the heat of mixing solid BaO_2 with aqueous hydrochloric acid, and the heat of mixing the resultant solution with aqueous barium nitrite. These data yield, for HNO_2 (aq.) $Q_f = 27.8$. Berthelot's data on the reaction between aqueous potassium permanganate and an aqueous nitrite solution yield, for HNO_2 (aq.), $Q_f = 28.4$. These three foregoing values for aqueous nitrous acid depend upon the accuracy of Thomsen's value for the reaction between gaseous chlorine and aqueous N_2O_4 (see above).

Both Berthelot²⁸ and Thomsen^{13, 15} measured the heat of the reaction

of decomposing ammonium nitrite, but because the former employed only a small amount of ammonium nitrite and used less refined apparatus, we have used only Thomsen's data. Thomsen apparently measured the heat of the reaction $(\text{NH}_4\text{NO}_2 + 2.8 \text{ H}_2\text{O}) (\text{liq.}) = \text{N}_2 (\text{g}) + 2.8 \text{ H}_2\text{O} (\text{liq.})$. We have carefully reviewed his data on this reaction, and utilizing Thomsen's value for the heat of solution of solid ammonium nitrite in $2.8 \text{ H}_2\text{O}$, we have computed $Q = 72.04$ for the reaction $\text{NH}_4\text{NO}_2 (\text{c}) = \text{N}_2 (\text{g}) + 2 \text{ H}_2\text{O} (\text{liq.})$. With this we have combined the heat of solution of ammonium nitrite in $200 \text{ H}_2\text{O}$ and the heat of ionization of HNO_2 , and have obtained, for $\text{HNO}_2 (\text{aq.})$, $Q_f = 31.6$, which is in marked disagreement with the values obtained above.

Swietoslawski⁶ measured the heats of the reactions, $((\text{NH}_2)_2\text{CO} + 2 \text{ HCl}) (\text{aq.}) + 2 \text{ NaNO}_2 (\text{aq.}) = \text{CO}_2 (\text{g}) + \text{N}_2 (\text{g}) + 3 \text{ H}_2\text{O} (\text{liq.}) + 2 \text{ NaCl} (\text{aq.})$ and $(\text{NH}_2)_2\text{CO} (\text{aq.}) + 2 \text{ HCl} (\text{aq.}) = ((\text{NH}_2)_2\text{CO} + 2 \text{ HCl}) (\text{aq.})$, finding, respectively, $Q = 172.6$ and 0.37 . Combining with these data, the heat of combustion and of solution of urea and the heat of mixing aqueous sodium nitrite with aqueous hydrochloric acid, we have computed, for $\text{HNO}_2 (\text{aq.})$, $Q_f = 28.9$. Swietoslawski⁶ also measured the heat of the reaction $(\text{CH}_3)_2\text{NC}_6\text{H}_5 (\text{liq.}) + \text{HNO}_2 (\text{aq.}) = \text{H}_2\text{O} (\text{liq.}) + \text{NOC}_6\text{H}_4\text{N} (\text{CH}_3)_2 (\text{liq.})$. Utilizing Swietoslawski's own values for the heats of combustion of these two organic liquids, we have computed, for $\text{HNO}_2 (\text{aq.})$, $Q_f = 28.4$. This value can not be given great weight as it is a small difference between large numbers, but nevertheless it is in gratifying agreement with the previous values.

As the best value for the heat of formation of aqueous nitrous acid we have selected the value 28.5 , which is consistent with the above available data and with the value for aqueous nitric acid.

$\text{NO}_2^- (\text{aq.})$. The data of Klemenc and Hayek¹ on the conductivity of aqueous HNO_2 yield, for $\text{H}^+ (\text{aq.}) + \text{NO}_2^- (\text{aq.}) = \text{HNO}_2 (\text{aq.})$, $Q^6 = 4.48$, or $Q = 4.0$ at 18° ; whence for $\text{NO}_2^- (\text{aq.})$, $Q_f = 24.5$. Swietoslawski⁶ found, for $\text{NaNO}_2 (\text{aq.}) + \text{HCl} (\text{aq.}) = (\text{HNO}_2 + \text{NaCl}) (\text{aq.})$, $Q = 3.45$; whence for $\text{NO}_2^- (\text{aq.})$, $Q_f = 25.0$. From the value for $\text{NH}_4\text{NO}_2 (\text{aq.})$, we have deduced, for $\text{NO}_2^- (\text{aq.})$, $Q_f = 25.4$.

$\text{HNO}_3 (\text{aq.})$. Thomsen¹⁵ measured the heats of the reactions $\text{N}_2\text{O}_4 (\text{g}) = \text{N}_2\text{O}_4 (\text{aq.})$ and $5 \text{ N}_2\text{O}_4 (\text{aq.}) + 2 \text{ KMnO}_4 (\text{aq.}) + 2 \text{ H}_2\text{O} (\text{liq.}) = (2 \text{ Mn}(\text{NO}_3)_2 + 2 \text{ KNO}_3 + 4 \text{ HNO}_3) (\text{aq.})$. Neglecting the heats of mixing, his data yield, for $\text{HNO}_3 (\text{aq.})$, $Q_f = 48.9$. Thomsen¹⁵ also measured the heat of reaction between aqueous N_2O_4 and gaseous chlorine, and his data yield, for $\text{HNO}_3 (200)$, $Q_f = 49.41$. Berthelot²⁸ measured the heat of reaction between liquid N_2O_4 , gaseous chlorine, and water, and his data yield, for $\text{HNO}_3 (\text{aq.})$, $Q_f = 47.9$. Latimer and Ahlberg¹ calculated the entropy of aqueous $(\text{M}^+ + \text{NO}_3^-)$, in a hypothetical 1 molal solution, from data on the entropy of the solid MNO_3 (calculated from data on the heat capacity down to about -261°) and its heat and free energy of solution. Combination of the value of the entropy of aqueous $(\text{M}^+ + \text{NO}_3^-)$ with similar values for aqueous $(\text{M}^+ + \text{Cl}^-)$ and aqueous $(\text{H}^+ + \text{Cl}^-)$ gave the

entropy of aqueous ($\text{H}^+ + \text{NO}_3^-$). They combined this value with the entropies of hydrogen, nitrogen, and oxygen in their standard states, and computed the entropy of formation of aqueous ($\text{H}^+ + \text{NO}_3^-$). Combination of this last value with the value for the free energy of formation given by Lewis and Randall⁵ yields, for HNO_3 (aq.), $Q_f = 48.7$. As the best value for the heat of formation of HNO_3 (200), we have selected the value 49.1, which seems to be most consistent with the above data and with the reactions involving nitrous acid.

Data on the heat of dilution of aqueous nitric acid were obtained by Thomsen,¹⁵ Berthelot,¹⁷ Richards and Rowe,² Naudé,² Wrewskii and Faerman,¹ Berthelot,⁹ and Petersen.⁶ Bose² reviewed these data. Recently Rossini³ utilized the accurate measurements of Richards and Rowe² to obtain values from 25 to ∞ H_2O . We have utilized Thomsen's¹⁵ values in the range 0 to 25 H_2O .

HNO_3 (liq.). For the heat of solution of liquid HNO_3 in water Thomsen¹⁵ found 7.44₃₀₀ and Berthelot¹⁷ 7.14.

HNO_3 (c). Berthelot¹⁷ found the heat of fusion to be -0.60 at -47° .

HNO_3 (g). Berthelot¹⁷ gave -7.2 for the heat of vaporization of the liquid, obtained from data on the heats of solution of the gas and the liquid in water.

HNO_3 ($\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$). Hantzsch¹ measured the heat of solution in ether.

NH_4NO_2 (aq.). For the heat of neutralization of aqueous ammonia with aqueous nitrous acid, Berthelot²⁸ gave the value 9.1 at 12.5° , which he deduced from the heat of the reaction between aqueous ammonium sulfate and aqueous barium nitrite, for which no value was given. The foregoing value yields, for NH_4NO_2 (aq.), $Q_f = 56.9$.

NH_4NO_2 (c). Berthelot²⁸ measured the heat of solution to be $-4.75_{430}^{12.5}$, from which we have estimated -4.66_{200} at 18° .

$\text{H}_2\text{N}_2\text{O}_2$ (aq.). Berthelot¹⁰⁵ measured the heat of solution of $\text{CaN}_2\text{O}_2 \cdot 4\text{H}_2\text{O}$ (c) in bromine water and hydrochloric acid, respectively, and the difference of these two reactions leads to the reaction $\text{H}_2\text{N}_2\text{O}_2$ (aq.) $+ 4\text{H}_2\text{O}$ (liq.) $+ 4\text{Br}_2$ (liq.) $= (2\text{HNO}_3 + 8\text{HBr})$ (aq.), with $Q = 45.6$. Similar experiments with the strontium salt gave $Q = 46.4$. From the average of these values, we have computed, for $\text{H}_2\text{N}_2\text{O}_2$ (aq.), $Q_f = 8.4$.

N_2O_2^- (aq.). Berthelot¹⁰⁵ reported the heat of neutralization of the weak hyponitrous acid to be 15.6; whence we have computed, for N_2O_2^- (aq.), $Q_f = -3.5$.

N_2O_5 (c). Berthelot⁹ found $S = 16.7$.

N_2O_5 (liq.). Berthelot⁹ reported $S = 25.0$, but his sample must have contained water as liquid nitrogen pentoxide is not stable under his conditions. Berl and Saenger¹ measured the heat of solution of fuming nitric acid.

N_2O_5 (g). Berthelot⁹ reported the heat of sublimation of solid nitrogen pentoxide to be -13.2 . The vapor pressure data of Daniels and Bright¹ yield -13.8 .

NO₃ (g). Schumacker and Sprenger¹ deduced, for NO₃ (g), $Q_f = -13$, from activation energies of the monomolecular dissociation of gaseous N₂O₅, which is supposed to give gaseous NO₃.

NH₄NO₃ (aq.). The heat of neutralization of aqueous ammonia with aqueous nitric acid was measured by Hess,⁶ Andrews,^{1, 2, 11} Favre and Silbermann,³ Favre,³ Bouzat,¹ Berthelot,^{3, 4} and Thomsen.¹⁵ Thomsen's data are the most reliable, and yield $N = 12.40_{200}$. Data on the heat of dilution of aqueous ammonium nitrate were obtained by Pratt,¹ Jirsa and Diamant,¹ Thomsen,¹⁵ Tollinger,¹ Dunnington and Hoggard,¹ Mondain-Monval,^{2, 3} Lerner-Steinberg,¹ Rümelin,¹ Winkelmann,¹ and Fricke and Havestadt.¹ We have extrapolated the data to infinite dilution.

NH₄NO₃ (c, IV). The existing data on the heat of solution of ammonium nitrate in water are: Thomsen,¹⁵ -6.32_{200} ; van Deventer and van der Stadt,¹ -6.3 ; Favre and Silbermann,³ -5.3 ; Berthelot,¹³¹ -4.75_{400} .¹² See also Graham³ and Mondain-Monval.³ Cohen and Helder-mann⁴ reported values for concentrated solutions at 32.5°.

NH₄NO₃ (c, V). Bridgman^{6a} reported $T = -0.13_{\rightarrow IV}$.¹⁸

NH₄NO₃ (c, III). For the heat of transition of this crystalline form to NH₄NO₃ (c, IV), at 32.2°, Bridgman^{6a} gave 0.372; Cohen and Helder-mann, 0.399; Bellati and Romanese,⁴ 0.403; Mondain-Monval,² 0.40.

NH₄NO₃ (c, II). For the heat of transition of NH₄NO₃ (c, II) to NH₄NO₃ (c, III), Bridgman^{6a} gave 0.32⁸³; Steiner and Johnston,¹ 0.31⁸⁴.

NH₄NO₃ (c, I). For the transition of this form to NH₄NO₃ (c, II), Bridgman^{6a} gave 1.02¹²⁵; Steiner and Johnston,¹ 0.98¹²⁹. See also Atlas Powder Co.¹

NOCl (g). Briner and Pylkoff¹ (see also Briner²) measured the heat of the reaction, NOCl (g) + 2 KOH (aq.) = (KCl + KNO₂) (aq.) + H₂O (liq.), finding $Q = 32.0$. The later and apparently more accurate measurements of Trautz and Wackenheim¹ on the similar reaction with aqueous sodium hydroxide yield $Q = 37.1$. These data yield respectively, for NOCl (g), $Q_f = -7.7$ and -13.0 . Lewis and Randall⁵ reviewed the data of Sudborough and Miller,¹ Trautz,³ Vago,¹ Trautz and Hinck,^{1, 2} and Trautz and Wackenheim¹ on the equilibrium, NO (g) + $\frac{1}{2}$ Cl₂ (g) = NOCl (g), and deduced for this reaction $Q = 9.1$; whence, for NOCl (g), $Q_f = -12.5$. The recent equilibrium data of Dixon¹ on the same reaction yield $Q = 9.3$, whence, for NOCl (g), $Q_f = -12.3$. Trautz and Wackenheim¹ estimated for this reaction $Q = 8.7$, whence, for NOCl (g), $Q_f = -12.9$. See also Trautz and Schleiter.¹

NOCl (liq.). The vapor pressure data of Trautz and Gerwig¹ and Briner and Pylkoff¹ yield for the heat of vaporization -6.1 at about -15° .

NOBr (liq.). The data of Trautz and Dalal¹ on the heat of solution of liquid NOBr in aqueous KOH yield, for NOBr (liq.), $Q_f = -11.6$.

NOBr (g). We have estimated the heat of vaporization of the liquid to be -6.1 , whence, for NOBr (g), $Q_f = -17.7$. The data of Trautz and Dalal¹ on the equilibrium, NOBr (g) = NO (g) + $\frac{1}{2}$ Br₂ (g), are not very

consistent, but from them we have estimated for this reaction $Q=8$ to 9; whence, for NOBr (g) , $Q_f = -16.4$ to -17.4 .

NOBr_3 (liq.). The data of Trautz and Dalal¹ on the heat of solution of liquid NOBr_3 in aqueous KOH yield, for NOBr_3 (liq.), $Q_f = 1.7$.

NOBr_3 (g). We have estimated the heat of vaporization of the liquid.

$\text{NH}_2\text{OH} \cdot \text{HNO}_3$ (c). Berthelot and Andre² measured the heat of combustion of this substance in a bomb calorimeter, using naphthalene as an auxiliary combustible material. Correcting the heat of combustion of naphthalene to the modern value, we have computed for $\text{NH}_2\text{OH} \cdot \text{HNO}_3$ (c), $Q_f = 85.8$. Berthelot and Andre² measured the heat of solution of solid $\text{NH}_2\text{OH} \cdot \text{HNO}_3$ in water to be -5.93_{500} . Using the value 81 (see following) for $\text{NH}_2\text{OH} \cdot \text{HNO}_3$ (aq.), this gives for the solid, $Q_f = 86.9$.

$\text{NH}_2\text{OH} \cdot \text{HNO}_3$ (aq.). Thomsen¹⁵ measured the heat of reaction, $(\text{NH}_2\text{OH} \cdot \text{HNO}_3 + 6 \text{ AgNO}_3) \text{ (aq.)} + 10 \text{ NH}_3 \text{ (aq.)} = \text{N}_2 \text{ (g)} + \text{N}_2\text{O (g)} + 3 \text{ H}_2\text{O (liq.)} + 6 \text{ Ag (c)} + 10 \text{ NH}_4\text{NO}_3 \text{ (aq.)}$. Correcting Thomsen's data for the dissolved N_2 and N_2O , one finds $Q = 330.43$, whence, for $\text{NH}_2\text{OH} \cdot \text{HNO}_3$ (aq.), $Q_f = 82.2$.

$\text{NH}_2\text{OH} \cdot \text{HCl}$ (c). Swietoslawski⁴ measured the heat of reaction, $\text{NH}_2\text{OH} \cdot \text{HCl (c)} + \text{NaNO}_2 \text{ (aq.)} = 2 \text{ H}_2\text{O (liq.)} + \text{N}_2\text{O (g)} + \text{NaCl (aq.)}$, to be 65.8, whence, for $\text{NH}_2\text{OH} \cdot \text{HCl (c)}$, $Q_f = 74.2$.

$\text{NH}_2\text{OH} \cdot \text{HCl}$ (aq.). Berthelot and Matignon⁴ measured the heat of solution of the solid to be -3.31_{450}^{24} . Thomsen¹⁵ found -3.65_{200} . Combination with the preceding value gives, for $\text{NH}_2\text{OH} \cdot \text{HCl (aq.)}$, $Q_f = 70.9$ and 70.5, respectively.

$\text{NH}_2\text{OH} \cdot \text{H}^+$ (aq.). From the values for aqueous $\text{NH}_2\text{OH} \cdot \text{HNO}_3$ and $\text{NH}_2\text{OH} \cdot \text{HCl}$, one finds, for $\text{NH}_2\text{OH} \cdot \text{H}^+$ (aq.), $Q_f = 32.3$ and 31.2.

NH_2OH (aq.). Berthelot's⁴¹ data on the reaction between NH_2OH and KOH for which he gives few details, yield, for $\text{NH}_2\text{OH (aq.)}$, $Q_f = 17.7$. For the heat of neutralization of $\text{NH}_2\text{OH (aq.)}$ with HCl (aq.) , Thomsen¹⁵ gave 9.26_{200} ; Ellingson,¹ 9.48_{100} , 9.29_{400} ; Berthelot,⁴¹ 9.2^{24} . Using Thomsen's values, we have computed, for $\text{NH}_2\text{OH (aq.)}$, $Q_f = 21.7$.

NH_2OH (c). Berthelot and Matignon⁴ found $S = -3.8$.

$(\text{NH}_2\text{OH})_2 \cdot \text{H}_2\text{SO}_4$ (aq.). Berthelot⁴¹ measured the heat of mixing $2 \text{ NH}_2\text{OH (aq.)}$ with $\text{H}_2\text{SO}_4 \text{ (aq.)}$ to be 21.6 at 13° . Thomsen¹⁵ found for the reaction, $\text{Ba(OH)}_2(400) + (\text{NH}_2\text{OH})_2 \cdot \text{H}_2\text{SO}_4(600) = \text{BaSO}_4 \text{ (c)} + 2 \text{ H}_2\text{O (liq.)} + 2 \text{ NH}_2\text{OH (500)}$, $Q = 15.32$. From these data we have computed, for $(\text{NH}_2\text{OH})_2 \cdot \text{H}_2\text{SO}_4 \text{ (aq.)}$, $Q_f = 276.5$ and 276.7, respectively.

$\text{NH}_2\text{OH} \cdot \text{H}_2\text{SO}_4$ (aq.). Ellingson¹ found for the reaction, $\text{NH}_2\text{OH (aq.)} + \text{H}_2\text{SO}_4 \text{ (aq.)} = \text{NH}_2\text{OH} \cdot \text{H}_2\text{SO}_4 \text{ (aq.)}$, $Q = 11.45_{100}$ and 11.07_{400} . From these data we have computed, for $\text{NH}_2\text{OH} \cdot \text{H}_2\text{SO}_4 \text{ (aq.)}$, $Q_f = 244.3$.

$(\text{NH}_2\text{OH})_2 \cdot \text{H}_2\text{SO}_4$ (c). Berthelot⁴¹ found $S = -5.80_{900}^{13}$.

$\text{NH}_2\text{OH} \cdot \text{H}_2\text{SO}_4$ (c). Thomsen¹⁵ found $S = -0.96$.

$\text{N}_2\text{H}_4 \cdot \text{H}_2\text{SO}_4$ (c). Berthelot and Matignon³ measured the heat of combustion of hydrazine sulfate with camphor as the auxiliary combustible

substance. Correcting, as does Berthelot,¹⁰⁸ for the new values for the heat of combustion of camphor, we have computed, for $\text{N}_2\text{H}_4 \cdot \text{H}_2\text{SO}_4$ (c), $Q_f = 228.4$.

$\text{N}_2\text{H}_4 \cdot \text{H}_2\text{SO}_4$ (aq.). Berthelot¹⁰⁸ found for the heat of solution of the solid in water, -8.7_{2000}^{11} ; Bach¹ found -8.52_{1200}^{19} .

N_2H_4 (aq.). For the heat of mixing N_2H_4 (aq.) with H_2SO_4 (aq.), Bach¹ found 11.29. For the reaction between $\text{Ba}(\text{OH})_2$ (aq.) and $\text{N}_2\text{H}_4 \cdot \text{H}_2\text{SO}_4$ (aq.), Berthelot¹⁰⁸ found $Q = 25.7$. For the similar reaction with BaCl_2 (aq.), Bach found $Q = 7.48$. These data yield, for N_2H_4 (aq.), $Q_f = -3.25$. Jirsa¹ measured the heat of oxidation of hydrazine with silver oxide, N_2H_4 (aq.) + $2\text{Ag}_2\text{O}$ (c) = 4Ag (c) + N_2 (g) + $2\text{H}_2\text{O}$ (liq.), finding $Q = 118.5$. Hence, for N_2H_4 (aq.), $Q_f = -4.5$. Bach¹ measured the heat of the reaction, $3\text{N}_2\text{H}_4 \cdot \text{HCl}$ (aq.) + $2\text{K}_2\text{Cr}_2\text{O}_7$ (aq.) + 13HCl (aq.) = 3N_2 (g) + $14\text{H}_2\text{O}$ (liq.) + $(4\text{KCl} + 4\text{CrCl}_3)$ (aq.), to be 465.2. Combining with this reaction Bach's¹ value for the reaction, N_2H_4 (aq.) + HCl (aq.) = $\text{N}_2\text{H}_4 \cdot \text{HCl}$ (aq.), $Q = 9.60$, yields, for N_2H_4 (aq.), $Q_f = -5.8$. Bach¹ also claimed to have measured the heat of the extraordinary reaction, $6\text{N}_2\text{H}_4 \cdot \text{HNO}_3$ (aq.) + 6HNO_3 (aq.) + 21AgNO_3 (aq.) + 32NH_3 (aq.) = 21Ag (c) + $\frac{5}{2}\text{N}_2$ (g) + $33\text{NH}_4\text{NO}_3$ (aq.), to be 922.2. See also Thomsen.¹⁷

$\text{N}_2\text{H}_4 \cdot \text{HCl}$ (aq.). Bach¹ measured the heat of mixing aqueous hydrazine with aqueous hydrochloric acid.

$\text{N}_2\text{H}_4 \cdot \text{HCl}$ (c). Bach¹ measured the heat of solution.

$\text{N}_2\text{H}_4 \cdot 2\text{HCl}$ (aq.). Bach¹ measured the heat of mixing N_2H_4 (aq.) with 2HCl (aq.).

$\text{N}_2\text{H}_4 \cdot 2\text{HCl}$ (c). Bach¹ measured the heat of solution.

$\text{N}_2\text{H}_4 \cdot \text{H}_2\text{O}$ (c). Bach¹ measured the heat of solution.

$\text{N}_2\text{H}_4 \cdot \text{HNO}_3$ (aq.). Bach¹ measured the heat of mixing N_2H_4 (aq.) with HNO_3 (aq.).

$\text{N}_2\text{H}_4 \cdot 2\text{HNO}_3$ (aq.). Bach¹ measured the heat of mixing N_2H_4 (aq.) with 2HNO_3 (aq.).

NH_3HN_3 (c). Berthelot and Matignon³ measured the heat of combustion of ammonium azide, NH_3HN_3 (c) + O_2 (g) = N_2 (g) + $2\text{H}_2\text{O}$ (liq.). Berthelot¹⁰⁷ corrected the original data on this reaction, obtaining $Q = 157.0$; whence, for NH_3HN_3 (c), $Q_f = -20.2$.

NH_3HN_3 (aq.). For the heat of solution of solid ammonium azide, Berthelot and Matignon³ found -7.08_{700}^{12} and Bach¹ -6.73_{600}^{17} .

HN_3 (aq.). Bach¹ found for the reaction, NH_3HN_3 (aq.) + HCl (aq.) = $(\text{NH}_4\text{Cl} + \text{HN}_3)$ (aq.), $Q = 3.97$; whence, for HN_3 (aq.), $Q_f = -54.6$.

$\text{NH}_4\text{X} \cdot n\text{NH}_3$ (c). The values for the heats of dissociation of the ammonium halides are computed from the dissociation pressure data of Troost¹ and Roozeboom.⁷

$\text{NH}_4\text{NO}_3 \cdot 5\text{NH}_3$ (liq.). The heat of dissociation of this substance is computed from the dissociation pressure data of Troost.²

NCl_3 (CCl_4). Deville and Hautefeuille¹ measured the heats of two

reactions involving nitrogen trichloride: $\text{NH}_4\text{Cl (c)} + 3\text{Cl}_2 \text{ (aq.)} = 4\text{HCl (aq.)} + \text{NCl}_3 \text{ (liq.)}$ and $\text{NH}_4\text{Cl (c)} + 3\text{HClO (aq.)} = \text{HCl (aq.)} + 3\text{H}_2\text{O (liq.)} + \text{NCl}_3 \text{ (liq.)}$. The observed heat values were 10.85 and 40.9, respectively, but there is considerable doubt about the second reaction. As written above, these data yield for $\text{NCl}_3 \text{ (liq.)}$, $Q_f = -56.1$ and -43.3 . Thomsen⁵ corrected an error in the original calculations of Deville and Hautefeuille, but made another error at the same time. The recent accurate data of Noyes and Tuley¹ on the reaction, $\text{NCl}_3(\text{CCl}_4) + 4\text{HCl (g)} = \text{NH}_4\text{Cl (c)} + 3\text{Cl}_2 \text{ (g)}$, give $Q = 41.8$; whence, for $\text{NCl}_3(\text{CCl}_4)$, $Q_f = -55.0$.

$\text{N}_2\text{O}_3 \cdot (\text{SO}_3)_2 \text{ (c)}$. Vaughan¹ measured the heat of solution of this substance in aqueous KOH.

$\text{HNO}_3 \cdot n\text{H}_2\text{SO}_4 \cdot n'\text{H}_2\text{O (liq.)}$. McDavid¹ measured the heat of mixing aqueous nitric and sulfuric acids in various proportions.

PHOSPHORUS

P (c, I, yellow). Standard state.

P (c, II, yellow). Bridgman² reported the heat of transition.

P (c, red). The exact thermodynamic status of the solid forms of phosphorus other than yellow has not yet been determined. The vapor pressure of red phosphorus was measured by Chapman¹ and Troost and Hautefeuille¹; and the latter calculated, from the difference in the temperature coefficients of the vapor pressures of the yellow and red forms, the heat of transition from yellow to red to be 4.2 at 700°. From the difference in the heats of combustion of the yellow and red forms of phosphorus, Giran¹ found $T = 3.7$. A more direct measurement of the heat of transition is that from the data of Giran¹ on the heats of reaction of the two forms with bromine in carbon disulfide, $Q = 38.79$ and 43.01 for the red and yellow forms, respectively. These data yield $T = 4.22$. Giran¹ found that the so-called violet or black phosphorus had a heat of reaction of 38.56 with bromine in carbon disulfide. Apparently this form is thermochemically identical with the red form.

P (liq., yellow). The existing data on the heat of fusion of P (c, I, yellow) are: Person,¹ $-0.156^{4.2}$; Desaine,² $-0.16^{4.4}$; Peterson,⁴ $-0.147^{4.4}$; Tammann,³ $-0.152^{4.1}$.

P₄ (g). Phosphorus molecules at saturation pressure below the boiling point are practically all tetratomic, according to the vapor density measurements of Deville and Troost,^{1,2} Meyer and Biltz,¹ Chapman,¹ Preuner and Brockmoller,¹ Stock, Gibson, and Stamm,¹ Hittorf,¹ Truthe,¹ and Mitscherlich.¹ The vapor pressure data of Centnerszwer,¹ MacRae and Voorhis,¹ and Smits and Bokhorst² on solid phosphorus yield -15.1 for the heat of sublimation. Vapor pressure data on liquid phosphorus were reported by Jolibois,¹ Schrötter,¹ MacRae and Van Voorhis,¹ Marckwald and Helmholtz,¹ Preuner and Brockmoller,¹ and Smits and Bokhorst.¹ For the heat of vaporization of liquid phosphorus to give gaseous P₄ at 300°, Preuner and Brockmoller¹ gave -12.5 , Smits and Bok-

horst² gave -12.5 , de Forcrand³⁷ calculated -12.2 , and we have computed -12.6 .

P₂ (g). From vapor density measurements, Preuner and Brockmoller¹ deduced, for the reaction, $P_4(g) = 2P_2(g)$, $Q^{800} = -31.5$. Assuming $\Delta C_p = 3$, we have computed $Q = -30.0$ at 18° .

P (g). From vapor density data, Preuner and Brockmoller¹ deduced for the reaction, $P_2(g) = 2P(g)$, $Q^{1400} = -45.5$. Taking $\Delta C_p = 3$, we have computed $Q = -42.2$ at 18° .

The ionization potentials of P (gas) are evaluated from the following: first step, Saltmarsh,¹ McLennan and McLay,¹ Kiess²; second step, Bowen³; third step, Bowen and Millikan,¹ Millikan and Bowen¹; fourth step, Bowen and Millikan¹; fifth step, Bowen and Millikan.²

P₂ (CS₂). Giran¹ measured the heat of solution of yellow phosphorus in carbon disulfide.

P₂O₅ (c). Data on the heat of combustion of phosphorus were reported by Favre and Silbermann,¹² Abria,¹ Andrews,^{14, 16} Troost and Hautefeuille,⁷ Berthelot,⁵⁰ and Giran.¹ The best of these data are undoubtedly those of Giran,¹ who measured the heats of combustion in a bomb calorimeter, the energy equivalent of which was determined by burning naphthalene. The result given by Giran¹ is not labeled either for constant volume or for constant pressure, but he uses the value in the latter sense, so we have assumed that he made the correction to constant pressure. Correction of his data to new atomic weights and for the new value for the heat of combustion of naphthalene yields, for the P_2O_5 formed in his bomb, $Q = 366.4$. Giran¹ found the difference in the heats of solution of the above form and the crystalline form of P_2O_5 to be -6.42 , so that, for $P_2O_5(c)$, we have computed $Q_f = 360.0$.

P₂O₅ (amorp.). Giran¹ found the heat of solution of the amorphous form of P_2O_5 to be 33.81 , as compared with 40.79 for the crystalline form under the same conditions. This gives for the reaction, $P_2O_5(c) = P_2O_5(\text{amorphous})$, $Q = 6.98$.

P₂O₅ (gls.). Giran¹ found the heat of solution of the vitreous form of P_2O_5 to be 29.09 , as compared with 40.79 for the crystalline form under the same conditions. This gives, for $P_2O_5(c) = P_2O_5(\text{gls.})$, $Q = 11.70$.

P₂O₅ (g). The vapor pressure data of Hoeflake and Scheffer¹ (see also Hautefeuille and Perry¹ and Smits and Rutgers¹) yield, for the heat of sublimation, the following values for the various forms of solid P_2O_5 : metastable crystals, -22.8 ; vitreous form, -20.4 ; stable crystalline form, -36.9 . These data are in disagreement with our values for the various solid forms, and may be explained by assuming that equilibrium was not attained. The vapor density of phosphorus pentoxide is not known with any accuracy. The old data of Tilden and Barnett¹ and West¹ indicate association in the vapor.

HPO₃ (aq.). Giran¹ found that the solution of crystalline P_2O_5 in water, with $Q = 40.79$, resulted in the formation of aqueous metaphosphoric acid; whence, for $HPO_3(aq.)$, $Q_f = 234.6$.

HPO₃ (c). Giran¹ found the heat of solution in water to form aqueous metaphosphoric acid to be 9.76.

H₃PO₄ (aq.). In the presence of strong acids, sulfuric acid in particular, aqueous metaphosphoric acid is transformed into aqueous orthophosphoric acid. Giran¹ measured the heat of solution of solid HPO₃ in aqueous sulfuric acid to be 12.91. Hence, for the reaction, HPO₃ (aq.) + H₂O (liq.) = H₃PO₄ (aq.), $Q=3.15$, and for H₃PO₄ (aq.), $Qf=306.1$. Thomsen¹⁵ measured the heat of the reaction of phosphorus with aqueous HIO₃ to form a mixture of aqueous H₃PO₃ and H₃PO₄, and the heat of the reaction of bromine water with aqueous H₃PO₃: HIO₃ (aq.) + 1.6 P (c, yellow) + 2.4 H₂O (liq.) = H₃PO₃ (aq.) + 0.6 H₃PO₄ (aq.) + HI (aq.), H₃PO₃ (aq.) + Br₂ (aq.) + H₂O (liq.) = H₃PO₄ (aq.) + 2HBr (aq.). We have computed Thomsen's data on these reactions, obtaining $Q=205.2$ and 64.9, respectively. The sum gives for the reaction, HIO₃ (aq.) + 1.6 P (c, yellow) + 3.4 H₂O (liq.) + Br₂ (aq.) = 1.6 H₃PO₄ (aq.) + 2HBr (aq.) + HI (aq.), $Q=270.1$, whence, for H₃PO₄ (aq.), $Qf=306.2$. Data on the heat of dilution of aqueous H₃PO₄ were reported by Thomsen.

H₃PO₄ (liq.), H₃PO₄ (c). Thomsen¹⁵ measured the heats of solution. Rideal¹ calculated the heat of fusion to be -2.87 .

H₃PO₄ · $\frac{1}{2}$ H₂O (c). Thomsen¹⁵ measured the heat of solution.

H₃PO₄ · $\frac{1}{2}$ H₂O (liq.). Thomsen¹⁵ measured the heat of solution.

H₃PO₃ (aq.). Thomsen's¹⁵ data on the reaction between aqueous bromine and aqueous phosphorous acid, $Q=64.9$, yield, for H₃PO₃ (aq.), $Qf=229.0$. Thomsen¹⁵ measured the heats of the following reactions: PCl₃ (liq.) + Cl₂ (g) = PCl₅ (c), PCl₅ (c) + 4H₂O (liq.) = (H₃PO₄ + 5HCl) (aq.), and PCl₃ (liq.) + 3H₂O (liq.) = (H₃PO₃ + 3HCl) (aq.). Combining these equations and neglecting the heats of mixing gives H₃PO₃ (aq.) + Cl₂ (g) + H₂O (liq.) = H₃PO₄ (aq.) + 2HCl (aq.). These data yield, for H₃PO₃ (aq.), $Qf=228.8$.

H₃PO₃ (liq.), H₃PO₃ (c). Thomsen¹⁵ measured the heat of solution of the solid and liquid in water.

P₂O₃ (g). The vapor pressure data of Schenck, Mihr, and Balthien,¹ when plotted as the logarithm of the pressure against the reciprocal of the absolute temperature, yield two straight lines of widely different slopes.

H₃PO₂ (aq.). Thomsen¹⁵ measured the heat of the reaction, BaH₄P₂O₄ · H₂O (c) + 4Br₂ (aq.) + 3H₂O (liq.) = (2H₃PO₄ + 6HBr + BaBr₂) (aq.), to be 277.4. Taking the heat of solution of the salt, and assuming the heats of neutralization of Ba(OH)₂(aq.) with HBr (aq.) and H₃PO₂ (aq.) to be 27.78 and 30.93, respectively, we have computed, for H₃PO₂ (aq.), $Qf=141.2$.

H₃PO₂ (c), H₃PO₂ (liq.). Thomsen¹⁵ measured the heats of solution of the solid and the liquid.

H₄P₂O₅ (aq.). Amat¹ found the heat of hydration of pyrophosphorous acid, H₄P₂O₅ (aq.) + H₂O (liq.) = 2H₃PO₂ (aq.), to be 4.9; whence, for H₄P₂O₅ (aq.), $Qf=384.3$.

$\text{H}_4\text{P}_2\text{O}_6$ (aq.). There are no data with which to compute the heat of formation of aqueous hypophosphoric acid.

$\text{H}_4\text{P}_2\text{O}_6$ (c). Joly² measured the heat of solution of the solid.

$\text{H}_4\text{P}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$ (c). Joly² measured the heat of solution of the solid.

$\text{H}_4\text{P}_2\text{O}_6 \cdot 2\text{H}_2\text{O}$ (liq.). Joly² measured the heat of solution of the liquid.

$\text{H}_4\text{P}_2\text{O}_7$ (liq.). Giran¹ measured the heat of solution of the liquid.

$\text{H}_4\text{P}_2\text{O}_7$ (c). Giran¹ measured the heat of solution of the solid.

$\text{H}_4\text{P}_2\text{O}_7$ (aq.). In a manner similar to that used for converting metaphosphoric into orthophosphoric acid, Giran¹ found for the reactions, $\text{H}_4\text{P}_2\text{O}_7$ (liq.) + H_2O (liq.) = $2\text{H}_3\text{PO}_4$ (aq.) and $\text{H}_4\text{P}_2\text{O}_7$ (c) + H_2O (liq.) = $2\text{H}_3\text{PO}_4$ (aq.), $Q = 14.47$ and 12.35 , respectively.

$\text{H}_4\text{P}_2\text{O}_7 \cdot 1\frac{1}{2}\text{H}_2\text{O}$ (c). Giran¹ measured the heat of solution.

$\text{H}_4\text{P}_2\text{O}_7 \cdot 1\frac{1}{2}\text{H}_2\text{O}$ (liq.). Giran¹ measured the heat of solution of the liquid.

PCl_3 (liq.). Thomsen¹⁵ and Berthelot and Louguinine² measured the heat of solution of liquid PCl_3 in water to be 65.1 .

PCl_3 (g). Antoine^{2, 3} and Andrews¹⁴ found the heat of vaporization of liquid PCl_3 to be -6.9 and -7.1 , respectively. Vapor pressure data were reported by Regnault.^{4, 7}

PCl_5 (c). Thomsen¹⁵ and Berthelot and Louguinine² measured the heat of solution of this substance in water. Their data give $Q = 123.4$ for the reaction, PCl_5 (c) + $4\text{H}_2\text{O}$ (liq.) = $(\text{H}_3\text{PO}_4 + 5\text{HCl})$ (aq.), from which we have computed, for PCl_5 (c), $Q_f = 106.5$. Thomsen's¹⁵ data for the reaction, PCl_3 (liq.) + Cl_2 (g) = PCl_5 (c), $Q = 29.69$, yield, for PCl_5 (c), $Q_f = 106.6$. See also Andrews.¹⁶

PCl_5 (g). Smith and Lombard² reported the value -15.5 for the heat of sublimation of solid PCl_5 , corrected for dissociation. The data of Smith and Calvert¹ show that gaseous PCl_5 is partly dissociated. The equilibrium data of Mitscherlich,¹ Cahours,¹ Deville,^{1, 2, 3} Naumann,^{1, 3} Horstmann,² Gibbs,² Wichelhaus,¹ Troost and Hautefeuille,^{9, 10, 11} Debray,¹ Wurtz,¹ Brill,³ Smith and Lombard,² and Holland¹ yield for the reaction, PCl_3 (g) + Cl_2 (g) = PCl_5 (g), $Q = 21 \pm 2$.

PBr_3 (CS_2). Giran¹ measured the heat of the reaction of liquid bromine with yellow phosphorus, each dissolved in carbon disulfide, to be 43.5 .

PBr_3 (liq.). Berthelot and Louguinine² measured the heats of solution of liquid PBr_3 in water and in aqueous KOH to be 64.0 and 130.5 , respectively, from which we have computed, for PBr_3 (liq.), $Q_f = 45.7$ and 48.8 , respectively.

POCl_3 (liq.). For the heat of solution in water, Thomsen¹⁵ found 72.19_{1000} ²⁰; Berthelot and Louguinine,² 74.6 .

POCl_3 (c). Oddo¹ computed the heat of fusion to be $-3.2^{1.7}$, from data on the freezing point lowering.

POCl_3 (g). Arie¹ calculated the heat of vaporization of the liquid to

be -8.70^{25} , from vapor pressure data. Calculation by way of Trouton's rule yields $-8.1^{100.7}$.

PBr₃ (c). Ogier⁴ reported the heat of solution to be 14.7.

POBr₃ (c). Ogier⁴ reported the heat of solution to be 79.7.

PI₂ (c). The data of Ogier⁴ and Berthelot and Louguinine² yield, for this substance, $Q_f = 10.9$.

PI₃ (CS₂). Ogier⁴ measured the heat of solution in carbon disulfide.

PH₃ (g). The data of Ogier,¹ who measured the heat of reaction between gaseous phosphine and saturated bromine water, yield, for PH₃ (g), $Q_f = -3.6$. Lemoult¹⁰ measured the heat of combustion of phosphine in oxygen to form H₃PO₄, and his data yield, $Q = 309.8$, whence, for PH₃ (g), $Q_f = -6.3$. The equilibrium data of Ipat'ev and Frost¹ on the reaction, $4\text{PH}_3\text{ (g)} = \text{P}_4\text{ (g)} + 6\text{H}_2\text{ (g)}$, yield $Q = -22.66$, whence, for PH₃ (g), $Q_f = 2.34$. We have been unable to interpret similar data obtained by Drummond.¹

PH₃ (liq.). The data of McIntosh and Steel¹ and Henning and Stock¹ yield $V = -3.9^{80}$.

P₂H (c). Ogier¹ found for the heat of reaction of solid P₂H with saturated bromine water $Q = 367.2$; whence, for P₂H (c), $Q_f = 11.9$.

PH₄I (c). Ogier¹ measured the heat of solution to be -4.77 , whence, for PH₄I (c), $Q_f = 20.4$. The dissociation pressure data of Smith and Calvert¹ yield $Q = 12.2$, and, assuming that the vapor is completely dissociated into PH₃ (g) and HI (g), we have computed, for PH₄I (c), $Q_f = 20.9$.

PH₄Br (c). Ogier¹ measured the heat of solution to be -3.03 , whence, for PH₄Br (c), $Q_f = 33.8$. The dissociation pressure data of Johnson² yield $Q = 24.0$, whence, assuming complete dissociation into PH₃ (g) and HBr (g), $Q_f = 34.9$. Vapor density measurements indicate that the vapor is not completely dissociated.

PH₄Cl (g). From vapor density data, Briner^{1, 3, 4} computed, for HCl (g) + PH₃ (g) = PH₄Cl (g), $Q = 16.4$. See also Tammann^{1, 3} and Scheffer.⁵

PH₄Cl (c). Briner^{1, 3, 4} computed the heat of sublimation to be -27.0 .

PH₃ · 6 H₂O (c). The dissociation pressure data of Cailletet and Bordet¹ and de Forcrand and Taboury¹ yield $Q = -13.5$ for the reaction, $\text{PH}_3 \cdot 6 \text{H}_2\text{O (c)} = \text{PH}_3\text{ (g)} + 6 \text{H}_2\text{O (liq.)}$, at 0°.

P₃N₅ (c). Stock and Wrede¹ measured the heat of combustion to be 1099.4.

(NH₄)_nH_{3-n}PO₄ (aq.). Berthelot and Louguinine³ measured the heats of mixing aqueous H₃PO₄ with 1, 2, and 3 moles of aqueous NH₃, respectively.

(NH₄)_nH_{3-n}PO₄ (c). There are no data on the heats of solution of any of the ammonium phosphates. Warren,¹ from dissociation pressure data, computed for (NH₄)₃PO₄ (c) = NH₃ (g) + (NH₄)₂HPO₄, $Q = -9.40$, and for (NH₄)₂HPO₄ (c) = NH₃ (g) + NH₄H₂PO₄ (c), $Q = -19.05$.

ARSENIC

As (solid). There are at least three forms of solid arsenic: As (c, α), metallic, trigonal, of high density, stable; As (c, γ), yellow, cubic, of low density, analogous to yellow phosphorous; As (amorphous β), grey or mirrorlike. Another form, the brown, may be identical with the β form. As (c, α) is taken as the standard state. Peterson⁵ measured the heats of reaction of the various forms of arsenic with chlorine and with bromine, and concluded that for the γ to α transition, $T=3.53$, and for the γ to β transition, $T=4.12$. Berthelot and Engel¹ gave $T=1.0$ for the α to β transition. Laschtschenko⁷ reported, for the transition from α to γ , $T=-0.55^{740}$, or about -1.5 at 18° .

As₄ (g). The vapor pressure data of Preuner and Brockmoller,¹ Gibson,¹ Ruff and Mugdan,¹ Ruff and Bergdahl,¹ Horiba,² Goubau,¹ Heike,¹ Jonker¹ Jolibois,³ Krafft and Knocke,¹ and Rassow¹ yield -11.3^{400} for the heat of vaporization of liquid arsenic and -31.8^{400} for the heat of sublimation of the solid, both values computed for As₄ (g). According to the vapor density data (see following) arsenic vapor at or below the boiling point is practically all As₄.

As (liq.). From the above data on the heat of vaporization and sublimation is obtained the heat of fusion.

As₂ (g). The vapor density data of Mitscherlich,¹ Bineau,¹ Deville and Troost,² Mensching and Meyer,¹ Biltz and Meyer,¹ and Preuner and Brockmoller¹ yield for the reaction, $\text{As}_4(\text{g}) = 2 \text{As}_2(\text{g})$, $Q^{1000} = -25.0$, or about -21 at 18° .

As (g). The foregoing data yield for the reaction, $\text{As}_2(\text{g}) = 2 \text{As}(\text{g})$, $Q^{1000} = -38.0$, or about -35 at 18° . The values for the energy states of gaseous monatomic arsenic are from Meggers and de Bruin,¹ Rao, Gartlein, Pathabhiramiah, and Rao,¹ Rao,² Rao and Badami,¹ and Sawyer and Humphreys.¹

AsF₃ (c), AsF₅ (liq.). Ruff, Menzel, and Plant¹ reported values for the heats of fusion and vaporization.

AsCl₃ (liq.). Andrews¹⁶ and Thomsen¹⁵ measured the heat of reaction between gaseous chlorine and metallic arsenic. The latter's data yield $Q_f = 71.54$. Peterson⁵ reported 72.5.

AsCl₃ (g). The vapor pressure data of Baxter, Bezzenberger, and Wilson¹ and Maier¹ yield -7.50 for the heat of vaporization. The data of Beckmann¹ and Kolossowsky² on the elevation of the boiling point yield -8.08 . See also Regnault.^{6, 10}

H₃AsO₄ (aq.). Thomsen¹⁵ measured the heat of the reaction, $\text{As}(c, \alpha) + \frac{5}{2} \text{Br}_2(\text{liq.}) + 4 \text{H}_2\text{O}(\text{liq.}) = (5 \text{HBr} + \text{H}_3\text{AsO}_4)(\text{aq.})$, to be 83.7; whence, for $\text{H}_3\text{AsO}_4(\text{aq.})$, $Q_f = 214.5$. The data of Berthelot and Engel¹ on the same reaction yield about the same value.

As₂O₅ (aq.). This is taken as equivalent to $2 \text{H}_3\text{AsO}_4(\text{aq.}) - 3 \text{H}_2\text{O}(\text{liq.})$.

As₂O₅ (c). Thomsen¹⁵ measured the heat of solution in 12 NaOH (200).

As₂O₃ (aq.). The data of Thomsen¹⁵ yield, for the heat of oxidation of aqueous arsenious acid with aqueous iodic acid, $Q = 148.5$, which gives, for As₂O₃ (aq.), $Qf = 146.9$. Berthelot¹⁵¹ reported $Q = 52.6$ for the heat of the reaction between aqueous arsenious acid and liquid bromine; whence, for As₂O₃ (aq.), $Qf = 148.4$. Thomsen¹⁵ measured the heat of solution of AsCl₃ (liq.) in water to be 17.58, whence, for As₂O₃ (aq.), $Qf = 147.0$.

As₂O₃ (c, octahedral). Schuhmann¹ measured the electromotive force at various temperatures for the cell in which the reaction was $2 \text{As (c, } \alpha) + 3 \text{H}_2\text{O (liq.)} = \text{As}_2\text{O}_3 \text{ (c, octahedral)} + 3\text{H}_2 \text{ (g)}$, and computed $Q = 51.0$, from which, for As₂O₃ (c, octahedral), $Qf = 154.1$. Thomsen¹⁵ measured the heat of solution of octahedral arsenic trioxide in four normal sodium hydroxide to be 7.52, from which, for As₂O₃ (c, octahedral), $Qf = 154.1$.

As₂O₃ (g), As₄O₆ (g). According to Mitscherlich¹ and Biltz⁷ the vapor of arsenic trioxide is mostly As₄O₆ at low temperatures and mostly As₂O₃ at high temperatures. Vapor pressure data were reported for both the solid and liquid forms by Rushton and Daniels,¹ Smellie,¹ Stelzner,¹ Niederschulte,¹ Welch and Duschak,¹ and Biltz.⁷ From the data of Biltz, we have computed for the reaction, $\text{As}_4\text{O}_6 \text{ (g)} = 2 \text{As}_2\text{O}_3 \text{ (g)}$, $Q = -17$.

As₂O₃ (c, monoclinic). We have estimated the heat of transformation into the octahedral form from the above vapor pressure data.

As₂O₃ (liq.). The above vapor pressure data yield a surprisingly large value for the heat of fusion of solid arsenic trioxide.

AsBr₃ (c). Berthelot⁵⁰ measured the heat of solution in aqueous KOH to be 59.8 at 9°.

AsBr₃ (liq.). Tolloczko and Meyer¹ reported a value for the heat of fusion of the solid.

AsBr₃ (g). The meager vapor pressure data of Walden² and Jager¹ yield -11.0 for the heat of vaporization. Trouton's rule gives -10.0 .

AsI₃ (c). Berthelot⁵⁰ measured the heat of solution in aqueous KOH to be 46.2 at 9°.

AsI₃ (liq.). We have estimated the heat of fusion.

AsI₃ (g). The vapor pressure data of Horiba and Inouye¹ yield -19.2 for the heat of vaporization of the liquid.

AsH₃ (g). Ogier² measured the heat of reaction of arsine with liquid bromine and water to be 212.9.

AsH₃ · 6 H₂O (c). de Forcrand⁴⁹ determined the heat of dissociation of the hexahydrate.

ANTIMONY

Sb (c). The metallic trigonal form is taken as the standard state. There is apparently a transition between 100° and 150°, but no thermal data on it are recorded. Another form of antimony is the so-called

"explosive" form prepared by electrolysis, and its heat of transformation into the metallic trigonal form is given by several investigators: Pebal,¹ 2.52; Cohen and Strengers,¹ 2.32 by direct measurement, and 2.56 from the difference in the heats of reaction with bromine.

Sb (liq.). The data on the heat of fusion of solid antimony at its melting point, 630°, are: Wust, Meuthen, and Durrer,¹ -4.67; Umino,⁴ -4.9; Laschtschenko,⁵ -4.85; Awbery and Griffiths,¹ -2.9. See also Herz.²

Sb₂ (g). The vapor pressure data of Greenwood,^{2, 5} van Liempt,² Ruff and Bergdahl,¹ and Ruff and Mugdan¹ were reviewed by Johnston, Fenwick, and Leopold,¹ and yield -45.2¹²⁰⁰ for the heat of vaporization of the liquid. According to Meyer and Biltz,¹ the vapor near the boiling point, 1440°, contains some Sb₄ molecules but is mostly Sb₂. We have estimated, for Sb₂ (g), $Q_f = -52$.

Sb (g). For the reaction $\text{Sb}_2 (\text{g}) = 2 \text{Sb} (\text{g})$, we have estimated $Q = -27$. The values for the ionization potentials are from the following: first step, Green and Loring,² see also Ruark, Mohler, Foote, and Chenaault¹; second and third steps, Dhavale,² Lang,^{2, 4, 5} Rao,¹ Nayaran and Rao,¹ and Gibbs and Vieweg¹; fourth step, Gibbs and Vieweg,¹ Badami,¹ and Lang^{1, 3}; fifth step, Badami,¹ and Lang.⁶ See also Bacher and Goudsmit.¹

SbCl₃ (c). Andrews¹⁶ and Thomsen¹⁵ measured the heat of reaction of solid antimony with gaseous chlorine. The data of the latter yield, for SbCl₃ (c), $Q_f = 91.39$.

SbCl₃ (liq.). Tolloczko,^{1, 2} from cryoscopic and calorimetric measurements, deduced the heat of fusion of the solid to be -3.01⁷³. Rideal¹ calculated -3.40.

SbCl₃ (g). The vapor pressure data of Braune and Tiedje,¹ Maier,¹ and Rotinyanz and Suchodskii¹ yield $V = -10.95^{125}$.

SbCl₅ (liq.). Thomsen¹⁵ found $Q = 13.48$ for the reaction $\text{SbCl}_3 (\text{c}) + \text{Cl}_2 (\text{g}) = \text{SbCl}_5 (\text{liq.})$.

SbCl₅ (c). The cryoscopic data of Moles¹ and Beckmann² yield $F = -2.45^{-6.0}$.

SbCl₅ (g). The vapor pressure data of Braune and Tiedje¹ yield $V = -11.05^{97}$, giving, for SbCl₅ (g), $Q_f = 93.82$. The equilibrium data of Braune and Tiedje¹ yield $Q = -16.30$ for the reaction, $\text{SbCl}_5 (\text{g}) = \text{SbCl}_3 (\text{g}) + \text{Cl}_2 (\text{g})$; whence, for SbCl₅ (g), $Q_f = 93.7$.

Sb₂O₃ (aq.). Thomsen¹⁵ measured the heats of the reactions, $4 \text{SbCl}_3 (\text{c}) + 5 \text{H}_2\text{O} (\text{liq.}) = \text{Sb}_4\text{O}_5\text{Cl}_2 (\text{c}) + 10 \text{HCl} (\text{aq.})$ and $\text{Sb}_4\text{O}_5\text{Cl}_2 (\text{c}) + 2 \text{NaOH} (\text{aq.}) = \text{H}_2\text{O} (\text{liq.}) + (2 \text{NaCl} + 2 \text{Sb}_2\text{O}_3) (\text{aq.})$, to be 8.91 and 22.75, respectively; whence, for $4 \text{SbCl}_3 (\text{c}) + 4 \text{H}_2\text{O} (\text{liq.}) + 2 \text{NaOH} (\text{aq.}) = 10 \text{HCl} (\text{aq.}) + (2 \text{NaCl} + 2 \text{Sb}_2\text{O}_3) (\text{aq.})$, $Q = 31.66$, and for Sb₂O₃ (aq.), $Q_f = 166.3$.

Sb₂O₃ (c, orthorhombic). Guntz^{1, 7} measured the heats of solution of SbCl₃ (c) and of Sb₂O₃ (c, orthorhombic) in concentrated aqueous HCl, and his data yield, for Sb₂O₃ (c, orthorhombic), $Q_f = 165.3$. Guntz^{1, 6, 7}

also measured the heats of solution of the same substances in aqueous HF and aqueous HCl+HF, respectively, and his data yield, for Sb_2O_3 (c, orthorhombic), $Q_f=164.5$. Mixer⁹ measured, in a bomb calorimeter, the heat of the reactions of antimony and antimony trioxide with sodium peroxide, and his data yield, for Sb_2O_3 (c, orthorhombic), $Q_f=167.0$. The dissociation pressure data of Baubigny¹ and Biltz¹ yield, for Sb_2O_3 (c, rhombic) $= 2\text{Sb (liq.)} + \frac{3}{2}\text{O}_2\text{ (g)}$, $Q = -167.4$, whence, for Sb_2O_3 (c, orthorhombic), $Q_f=153$, a value which is much too low.

Sb_2O_3 (c, octahedral). From the difference in the heats of solution of Sb_2O_3 (c, orthorhombic) and Sb_2O_3 (c, octahedral) in aqueous HF, Guntz⁷ found the heat of transformation of the former into the latter to be 1.2.

Sb_2O_5 (aq.). Thomsen¹⁵ found the heat of solution of SbCl_5 (liq.) in water to be 35.27, whence, for Sb_2O_5 (aq.), $Q_f=228.0$.

Sb_2O_5 (c). Mixer⁹ measured the heat of the reactions of antimony and antimony pentoxide with sodium peroxide, and his data yield, for Sb_2O_5 (c), $Q_f=235.7$.

Sb_4O_6 (g). Hincke,¹ from data on the vapor pressure of solid Sb_2O_3 , computed the following: $2\text{Sb}_2\text{O}_3$ (c, orthorhombic) $= \text{Sb}_4\text{O}_6$ (g), $Q = -44.08$; $2\text{Sb}_2\text{O}_3$ (c, cubic) $= \text{Sb}_4\text{O}_6$ (g), $Q = -47.32$; and $2\text{Sb}_2\text{O}_3$ (liq.) $= \text{Sb}_4\text{O}_6$ (g), $Q = -17.83$.

Sb_4O_6 (liq.). The vapor pressure data of Hincke¹ yield -13.6 for the heat of fusion of Sb_2O_3 (c, orthorhombic).

SbO (g). Mukherji¹ reported $D^\circ = -81$.

Sb_2O_4 (c). The data of Simon and Thaler¹ give $2\text{Sb}_2\text{O}_4$ (c) $= 2\text{Sb}_2\text{O}_3$ (c) $+ \text{O}_2$ (g), $Q^{1080} = -55.8$; whence, for Sb_2O_4 (c), $Q_f=193.3$. Mixer⁹ measured the heat of the reaction of antimony and antimony tetroxide with sodium peroxide, and his data yield, for Sb_2O_4 (c), $Q_f=213.0$.

Sb_6O_{13} (c). The data of Simon and Thaler¹ give $3\text{Sb}_2\text{O}_5$ (c) $= \text{Sb}_6\text{O}_{13}$ (c) $+ \text{O}_2$ (g), $Q^{400} = -25.5$, and $2\text{Sb}_6\text{O}_{13}$ (c) $= 6\text{Sb}_2\text{O}_4$ (c) $+ \text{O}_2$ (g), $Q^{730} = -39.3$. These values yield, for Sb_6O_{13} (c), $Q_f=664.5$ and 658.7 , respectively.

H_3SbF_6 (aq.). Guntz^{7, 1, 6, 7} data on the heat of solution of Sb_2O_3 (c, orthorhombic) in aqueous HF yield, for H_3SbF_6 (aq.), $Q_f=443.5$.

SbF_3 (c). Guntz^{7, 1, 6, 7} measured the heat of solution of SbF_3 (c) in 3 HF (aq.) to be 0.3.

SbF_3 (aq.). Guntz^{7, 1, 6, 7} measured the heat of solution of SbF_3 (c) in water to be -1.6_{200}^9 .

$\text{Sb}_4\text{O}_5\text{Cl}_2$ (c). Thomsen's¹⁵ data on the heat of solution of SbCl_3 (c) in water to form $\text{Sb}_4\text{O}_5\text{Cl}_2$ (c) and 10 HCl (aq.) yield, for $\text{Sb}_4\text{O}_5\text{Cl}_2$ (c), $Q_f=348.40$. Guntz^{7, 1} measured the heat of solution of $\text{Sb}_4\text{O}_5\text{Cl}_2$ (c) in aqueous HF but reported no experimental data. He computed for the reaction, $2\text{Sb}_2\text{O}_3$ (c, orthorhombic) $+ 2\text{HCl}$ (g) $= \text{Sb}_4\text{O}_5\text{Cl}_2$ (c) $+ \text{H}_2\text{O}$ (c), $Q=41.2$; whence, for $\text{Sb}_4\text{O}_5\text{Cl}_2$ (c), $Q_f=346.1$.

SbOCl (c). Guntz^{7, 1} measured the heat of solution of SbOCl (c) in aqueous HF, but reported no experimental data. He computed for the

reaction, Sb_2O_3 (c, orthorhombic) + 2HCl (g) = 2SbOCl (c) + H_2O (c), $Q = 38.8$; whence, for SbOCl (c), $Q_f = 89.2$.

$\text{SbF}_3 \cdot n \text{NH}_3$ (c). Biltz and Rahlfs² measured the dissociation pressures at various temperatures of the ammines with 1, 2, 3, 4, and 6 moles of NH_3 .

SbBr_3 (c). Guntz^{1, 7} measured the heat of solution of SbBr_3 in HF , but did not report the result of this experiment. Instead he gave $Q = 76.9$ for the reaction, Sb (c) + $\frac{3}{2} \text{Br}_2$ (g) = SbBr_3 (c). Making some assumptions as to the auxiliary data Guntz used in arriving at this value, we have computed, for SbBr_3 (c), $Q_f = 64.1$. Berthelot and Petit¹ dissolved SbBr_3 (c) in concentrated aqueous $\text{HCl} + \text{Br}_2$, finding $Q = 27.5$. Assuming that H_3SbO_4 (aq.) was formed, we have deduced, for SbBr_3 (c), $Q_f = 55.5$, which value is evidently too small. Combining the data of Cohen and Strengers¹ on the reactions, SbBr_3 (c) = SbBr_3 (CS_2), $Q = -3.6$, and Sb (c, trigonal) + $\frac{3}{2} \text{Br}_2$ (CS_2) = SbBr_3 (CS_2), $Q = 58.5$, we have obtained, for SbBr_3 (c), $Q_f = 60.0$.

SbBr_3 (liq.). Tolloczko and Meyer¹ and Tolloczko¹ gave -3.52^{100} for the heat of fusion of the solid. Rideal¹ calculated -3.60 .

SbBr_3 (CS_2). Cohen and Strengers¹ measured the heat of formation of SbBr_3 in carbon disulfide from antimony and bromine, Sb (c, trigonal) + $\frac{3}{2} \text{Br}_2$ (CS_2) = SbBr_3 (CS_2), to be 58.5; whence, for SbBr_3 (CS_2), $Q_f = 56.4$.

SbI_3 (c). Guntz⁸ gave 45.4 for the heat of the reaction, Sb (c, trigonal) + $\frac{3}{2} \text{I}_2$ (g) = SbI_3 (c), which he deduced from measurement of the heat of solution of SbI_3 (c) in aqueous HF . Making assumptions as to the subsidiary values used by Guntz,⁸ we have obtained, for SbI_3 (c), $Q_f = 22.8$.

SbI_3 (aq.). Mosnier¹ measured the heat of solution of SbI_3 (c) in water to be -0.88 .

SbH_3 (g). The data of Berthelot and Petit,¹ who measured the heat of solution of SbH_3 (g) in bromine water, yield for SbH_3 (g), $Q_f = -79.5$. Stock and Wrede¹ measured directly the heat of the explosive decomposition of gaseous SbH_3 into solid Sb and gaseous H_2 , and their data yield $Q_f = -34.0$.

Sb_2S_3 (c, yellow). Berthelot⁹⁹ found the heat of reaction of dilute aqueous SbCl_3 with H_2S to be variable, and he ascribed this behavior to the formation of compounds similar to SbSCl . Berthelot⁹⁹ measured the heat of the reaction of SbCl_3 (c) with $6 \text{C}_4\text{H}_6\text{O}_6$ (aq.) and of the resulting solution with aqueous H_2S , finding $Q = 13.74$ and 32.26 , respectively; whence, for Sb_2S_3 (c, yellow), $Q_f = 35.8$. Berthelot⁹⁹ also found the heat of reaction of SbCl_3 (c) with 12HCl (20) to be 4.17, and that of the resulting mixture with aqueous H_2S to be 9.39; whence, for Sb_2S_3 (c, yellow), $Q_f = 35.2$.

$\text{Sb}_2(\text{SO}_4)_3$ (c). Beck¹ measured the heat of solution of this substance in aqueous NaOH to be 118.7.

BISMUTH

Bi (c). Standard state.

Bi (liq.). The data on the heat of fusion of solid bismuth at the melting point, 271° , are: Person,⁹ -2.59 ; Person,^{2, 8} -2.64 ; Wust, Meuthen, and Durrer,¹ -2.14 ; Iitaka,¹ -2.55 ; Awbery and Griffiths,¹ -2.72 . From the cooling curve, Mazzotto³ deduced -2.59 ; and, from data on the change in melting point with pressure, Bridgman⁴ calculated -2.68 . See also Tammann⁴ and Johnston and Adams.¹

Bi₂ (g). The vapor density data of Biltz and Meyer^{1, 3} indicated that bismuth vapor at the boiling point is about $\frac{1}{2}$ Bi₂ + $\frac{1}{2}$ Bi. The vapor pressure data, for liquid bismuth, of Greenwood,³ Ruff and Bergdahl,¹ Ruff and Mugdan,¹ and Barus^{1, 2} yield -4.48 for the heat of vaporization at the boiling point. We have corrected this value for the amount of dissociation.

Bi (g). From spectroscopic data, Barratt and Bonar¹ obtained, for Bi₂ (g) = 2 Bi (g), $D^\circ = -18.5$. The values for the energy states of gaseous monatomic bismuth are taken from the following: first spectra, Thomsen³ and Toshniwal¹; second and third spectra, McLennan, McLay, and Crawford.² See also Bacher and Goudsmit.¹

BiCl₃ (c). Thomsen¹⁵ measured the heat of reaction of solid bismuth and gaseous chlorine, and his data give, for BiCl₃ (c), $Q_f = 90.61$.

BiCl₃ (aq. HCl). Tanatar⁸ measured the heat of solution of Bi₂O₃ (c) in excess HCl (25) to be 35.6. Assuming the reaction to be Bi₂O₃ (c) + 6 HCl (25) = 2 BiCl₃ (aq. HCl) + 3 H₂O (liq.), we have computed, for BiCl₃ (aq. HCl), $Q_f = 84.5$.

BiOCl (c). Thomsen's¹⁵ value for the heat of the reaction, BiCl₃ (c) + H₂O (liq.) = BiOCl (c) + 2 HCl (aq.), $Q = 7.83$, yields, for BiOCl (c), $Q_f = 87.8$. Noyes and Chow¹ measured the electromotive force at various temperatures of the cell in which the reaction was Bi (c) + HCl (aq.) + H₂O (liq.) = BiOCl (c) + $\frac{3}{2}$ H₂ (g), and calculated $Q = 18.50$; whence, for BiOCl (c), $Q_f = 89.4$.

Bi₂O₃ (c, hydrated). Thomsen¹⁵ measured the heat of reaction of Bi₂O₃ · n H₂O (c) with just enough aqueous HCl to form solid BiOCl to be 14.2, whence we have computed, for the hydrated oxide, $Q_f = 136.8$.

H₃ BiO₃ (c). Assuming the above hydrated oxide to be Bi₂O₃ · 3 H₂O (c), we have computed, for H₃BiO₃ (c), $Q_f = 171.1$.

Bi₂O₃ (c). Mixer⁹ measured, in a bomb calorimeter, the following: 2 Bi (c) + 5 Na₂O₂ (c) = 2 Na₃BiO₄ (c) + 2 Na₂O (c), $Q = 170.6$; Bi₂O₃ (c) + 2 Na₂O₂ (c) + Na₂O (c) = 2 Na₃BiO₄ (c), $Q = 92.8$. The difference gives 2 Bi (c) + 3 Na₂O₂ (c) = Bi₂O₃ (c) + 3 Na₂O (c), $Q = 77.8$; from which, for Bi₂O₃ (c), $Q_f = 137.1$.

BiO (c). Tanatar⁸ measured the heat of solution of BiO (c) in excess aqueous HCl to be 24.6.

Bi₂S₃ (c). From equilibrium data on the reaction, Bi₂S₃ (c) + 3 H₂ (g) = 2 Bi (liq.) + 3 H₂S (g), Jellinek and Zakowski¹ computed $Q = -18.1$; whence, for Bi₂S₃ (c), $Q_f = 29$.

Bi₂(SO₄)₃ (c). Beck¹ measured the heat of solution of this substance in aqueous NaOH to be 54.6.

BiI₃ (c). Mosnier¹ measured the heat of solution.

BiI₃ (aq.). We have estimated this value.

CARBON

C (c, diamond). We have selected diamond as the standard state for carbon because, with respect to heat content, it is the only truly reproducible form of solid carbon.

C (c, graphite). Roth¹⁰ found that the heat of combustion of graphite varies considerably with its source or manner of preparation. The results obtained by Roth,^{9, 10} Roth and Wallasch,¹ and Roth and Naeser¹ for the heats of combustion of graphite grouped themselves about two values; and Roth labeled those samples having the lower heat of combustion α graphite, and those having the higher heat of combustion β graphite. The differences in the values found by Roth and his coworkers for the heats of combustion of diamond, α graphite, and β graphite, when properly converted to true moles (see Rossini¹⁵) and to a pressure of 1 atmosphere (see Washburn²) yield 0.22 and 0.49 for the heats of transition at 18° of diamond to β graphite and to α graphite, respectively. The data of Roth,^{9, 10} Roth and Wallasch,¹ and Roth and Naeser¹ yield 94.45, 94.23, and 93.96 for the heats of the reaction, $C(c) + O_2(g) = CO_2(g)$, for diamond, β graphite, and α graphite, respectively, at 18° and a constant pressure of 1 atmosphere. The uncertainty in these values is apparently about ± 0.10 . Though some investigators used graphite degassed in air, Plummer¹ reported that such samples of graphite were partially oxidized. The older data on the heat of combustion of graphite are those of Favre and Silbermann,¹ Andrews,¹⁶ Grassi,¹ Berthelot and Petit,² and Mixter.³

C (c, carbonado). Roth and Naeser¹ measured the heat of combustion of carbonado (bort or black diamond), and their data yield for the reaction, $C(c, \text{carbonado}) + O_2(g) = CO_2(g)$, $Q = 94.55$.

C ("amorphous," charcoal). Thiele¹ studied the heat of combustion of charcoal prepared from sugar as a function of the temperature of preparation, and found that the heat of combustion was constant only for samples prepared above 1400°. The data of Thiele,¹ Mixter,³ and Favre and Silbermann,^{1, 5, 11} yield, respectively, 96.4, 96.6, and 96.4 for the heat of the reaction, $C(\text{"amorphous," charcoal}) + O_2(g) = CO_2(g)$. Data on the heat of combustion of this form of carbon were also reported by Peterson,^{1a} Despretz,¹ Berthelot and Petit,² Dulong,² Andrews,^{14, 16} Berthelot and Vielle,^{7, 12} Ruff and Gersten,² Thomsen,^{7, 16} Pfaunder,³ Nikiten,¹ and Lavoisier and Laplace¹ (see Mellor¹).

C ("amorphous," "acetylene" carbon). Mixter's data yield 94.7 for the heat of the reaction, $C(\text{"amorphous," "acetylene" carbon}) + O_2(g) = CO_2(g)$.

C ("amorphous," "Glanzkohlenstoff"). Roth and Doepke¹ measured the heats of combustion of samples of "Glanzkohlenstoff" of different

densities, and their data yield the following values for the heats of formation, from diamond as the standard state, of samples having the densities 2.07, 2.0, and 1.86 grams per cm³, respectively: -2.1, -2.3, and -3.2. See also Roth, Naeser, and Doepke.¹

C ("amorphous," "gas" carbon). Roth⁹ and Favre and Silbermann¹ measured the heat of combustion of this form of carbon, and their data yield for the reaction, C ("amorphous," "gas" carbon) + O₂ (g) = CO₂ (g), $Q = 95.93$ and 96.5 , respectively.

C₂ (g). The values for the energy of dissociation of C₂ (g) into 2C (g), with each substance in the normal or ground state, are, in volt-electrons, the following: Mulliken,³ 5.5; Birge,¹ 7.0; Johnson and Asundi,² 7.02; Vaughan and Kistiakowsky,¹ 7.43, 8.28, 6.78, and 6.97. The value for the energy of excitation of C₂ (g) is from Mulliken.³ See also Hori² and Lennard-Jones.¹

C (liq.). Ryschkewitsch^{1, 2} and Ryschkewitsch and Merck¹ obtained values for the vapor pressures of solid and liquid carbon at various temperatures by assuming that the partial pressure of gaseous carbon in the crater is equal to the external pressure. Their data on the difference in the slopes of the curves giving the logarithm of the pressure against the reciprocal of the absolute temperature for both solid and liquid carbon yield -11 for the heat of fusion of carbon at the melting point. Fajans⁶ estimated the value to be -10. There is now general agreement (see Ryschkewitsch,^{1, 2} Hagenback and Luthy,¹ Sauerwold,¹ Despretz,^{3, 4} Braun,¹ La Rosa,¹ Lummer,¹ Ruff,¹ and Munch¹) that the melting point of carbon is about 3580°.

C (g). The heat of formation of gaseous monatomic carbon can be computed from values of the heat of sublimation of carbon or of the energy of dissociation of gaseous CO into gaseous carbon and oxygen atoms.

Values for the heat of sublimation of carbon have been determined in three ways: (1), by estimation of the heat of vaporization from the boiling point and Trouton's constant, and combination with the heat of fusion; (2), by experimental determination of the vapor pressure at various temperatures, assuming that the partial pressure of gaseous carbon in the carbon arc is equal to the external pressure of the inert gas; (3), by experimental determination of the vapor pressure at various temperatures by measuring the rate of loss of carbon from a carbon filament heated to known temperatures, assuming an accommodation coefficient of 1. In each of these three methods there is required a knowledge of the relative concentrations of C₂ (g) and C (g) in the gaseous carbon, and of the energy of dissociation of C₂ (g) into 2C (g), in order that the heat of the reaction C (c) = C (g) may be calculated. Vaughan and Kistiakowsky¹ calculated that, if the energy of dissociation of C₂ (g) into 2C (g) is -160, the concentration of C (g) in gaseous carbon is 9.7 mole per cent at 3880° and 12.7 mole per cent at 4430°.

Calculation of the heat of sublimation of carbon at 18° from values

for the boiling point and Trouton's constant yields values ranging from -150 to -200 . The various published values for the boiling point of carbon range from 3900 to 5680° . Johnston, Fenwick, and Leopold¹ estimated the value $3930 \pm 100^\circ$, from a review of the then-published vapor pressure data. Other estimates are the following: Ryschkewitsch,² 3900° ; Kohn and Guckel,^{1, 2} 3930° ; Fajans,^{1, 2, 7} 4050° ; Herbst,¹ not less than 5700° ; van Laar,⁸ 5030° . See also Crookes,¹ Violle,⁵ Moissan,³ Mott,¹ and van Laar.^{1, 3, 6, 7}

Data on the change in vapor pressure of carbon with temperature, obtained by assuming the partial pressure of gaseous carbon in the carbon arc equal to the external pressure of the inert gas, were reported by Fajans,^{1, 7} Kohn,¹ Kohn and Guckel,^{1, 2} Thiele and Ritter,¹ Ryschkewitsch,² and Podszus.¹ These data yield values ranging from -140 to -190 for the heat of sublimation of carbon at 18° .

Data on the change in vapor pressure of carbon with temperature, obtained by measuring the rate of loss of carbon from a carbon filament heated to known temperatures, were reported by Wertenstein and Jedrzejewski,¹ Brody and Millner,^{1, 2} and Marshall and Norton.¹ These data yield values ranging from -160 to -210 for the heat of sublimation of carbon at 18° . Marshall and Norton¹ computed from their data the value -178 ± 1 for the heat of the reaction, $C(c, \text{graphite}) = C(g)$, at -273° .

Estimates of the heat of sublimation of carbon were made by Violle,^{2, 3, 4} Wilson,⁴ Wilson and Fitzgerald,¹ Wanner,¹ Watts and Mendenhall,¹ Lummer,¹ Fajans,⁷ Smithells,¹ Weimberg,¹ Gruneisen,¹ Padoa,¹ and Lande.² Most of the foregoing data were reviewed by Johnston, Fenwick, and Leopold,¹ who gave -129 for the heat of vaporization of liquid carbon in the range 3900 to 4400° .

Vaughan and Kistiakowsky¹ calculated by the statistical method, on the assumption that the published experimentally determined vapor pressures (but not the corresponding temperatures) of carbon were correct, that the heat of sublimation of carbon into gaseous atoms at -273° is -161 or -195 , depending upon whether the value 5.5 or 7.0 volt-electrons is taken as the energy of dissociation of $C_2(g)$ into $2C(g)$.

Birge and Sponer¹ extrapolated the vibrational levels of CO (from band spectra) and their data yield 10.2 volt-electrons for the energy of dissociation of CO. For this same quantity, Mulliken⁶ estimated 10.0 and Wiezel¹ 10.3 volt-electrons. Coster and Brons¹ obtained predissociation data in the $0-1$ Angstrom band of CO, and, assuming the products of dissociation of CO in the B state to be carbon and oxygen atoms each in the 1D state, deduced the energy of dissociation of CO to be 9.82 volt-electrons. The assumption that the products of dissociation are $C(^1D)$ and $O(^3P)$ yields the value of 11.06 volt-electrons. These predissociation data were confirmed by Read,¹ who set an upper limit of 11.05 volts for the energy of dissociation of CO. From electron bombardment experiments, Tate and Lozier¹ deduced 9.3 ± 0.5 volt-electrons for the

energy of dissociation of CO. The similar, but later and more accurate, data of Lozier² were subjected to two interpretations, one yielding the value 9.6 ± 0.1 and the other 11.6 ± 0.1 volt-electrons.

Because of the existing uncertainties in the data leading to the heat of formation of gaseous monatomic carbon, we have arbitrarily selected for the energy of dissociation of normal CO (g) into normal C (g) and O (g), the value $D^{\circ} = 11.06 - a'$ volt-electrons, or $-255.0 + a$ kilocalories per mole, where a is an unknown whose value at this writing may be as much as +60 kilocalories, so that, for C (g), $-110 > Q_f > -170$.

The energy states of gaseous monatomic carbon are evaluated from the data of Fowler and Selwyn,^{1, 2} Bowen,² Edlen,² Edlen and Stemnan,¹ Edlen and Ericson,⁵ Eckart,¹ and Paschen and Kruger.¹

CO (g). The heat of combustion of carbon monoxide was measured by Andrews,¹⁴ Grassi,² Lagerlof,¹ Dulong,² Favre and Silbermann,¹ Berthelot,^{45, 58} Berthelot and Matignon,¹¹ Thomsen,^{7, 10, 15, 16} Rossini,^{2, 5} Roth and Banse,² Fenning and Cotton,¹ and Awbery and Griffiths.² The last four named investigations were completed in the years 1930 to 1933, and all the others prior to 1904. The data of the modern determinations yield the following values for the heat of the reaction, $\text{CO (g)} + \frac{1}{2} \text{O}_2 \text{ (g)} = \text{CO}_2 \text{ (g)}$, at 18° and a constant pressure of 1 atmosphere: Rossini,^{2, 5} 67.61 ± 0.03 ; Roth and Banse,² 67.86 ± 0.20 ; Fenning and Cotton,¹ 67.65 ± 0.05 ; Awbery and Griffiths,¹ 67.58 ± 0.10 .

The energy states of CO (g) are evaluated from the data of Hund,¹ Mulliken,³ Johnson,⁴ Dunkel,¹ Birge,^{6, 7} Hopfield and Birge,¹ Duffendack and Fox,² Knauss,¹ Herzberg,² Johnson and Asundi,¹ Asundi,^{1, 2} Eastey,¹ Hepburn,¹ Kallman and Rosen,¹ Hogness and Harkness,¹ Dunkel,¹ and Birge and Sponer.¹

CO (liq.). Vapor pressure data on liquid carbon monoxide were reported by Olszewsky,^{7, 8} Wroblewsky,^{1, 5, 2} Baly and Donnan,¹ Clusius and Teske,¹ Hoppel,¹ Verschoyle,¹ Crommelin, Bijleveld, and Brown,¹ and Clayton and Giauque.¹ The calorimetric data on the heat of vaporization of liquid carbon monoxide are: Eucken,^{2, 3} -1.414 at -190° ; Clayton and Giauque,¹ -1.444 at -191.5° .

CO (c). Vapor pressure data on solid carbon dioxide were reported by Olszewsky,^{7, 8} Wroblewsky,^{1, 5, 2} Baly and Donnan,¹ Clusius and Teske,¹ Hoppel,¹ Verschoyle,¹ Crommelin, Bijleveld, and Brown,¹ and Clayton and Giauque.¹ The calorimetric data on the heat of fusion of CO (c, I) are: Eucken,^{2, 3} -0.224 at -205.8° ; Clusius,² -0.2015 at -204.9° ; Clayton and Giauque,¹ -0.1997 at -205.0° . The calorimetric data on the heat of transition of CO (c, II) to CO (c, I) are Eucken,^{2, 3} -0.144 at -212.9° ; Clusius,² -0.1512 at -211.6° ; Clayton and Giauque,¹ -0.1515 at -211.6° .

CO (aq.). Adolph and Henderson¹ calculated the heat of solution of gaseous carbon monoxide in water from the solubility-temperature data of Winkler⁸ and Bunsen.¹

CO₂ (g). The heat of combustion of diamond was measured by Ber-

thelot and Petit,^{2, 6} Favre and Silbermann,^{1, 4, 5, 11} Andrews,^{2, 7, 16} Roth and Wallasch,¹ and Roth and Naeser.¹ The modern data, those of Roth and his coworkers, yield 94.45 for the heat of the reaction, C (c, diamond) + O₂ (g) = CO₂ (g).

CO₂⁺ (g). Smyth and Steuckelberg¹ reported a value for the energy of the reaction, CO₂ (g) = CO₂⁺ (g) + θ .

CO₂ (liq.). Liquid carbon dioxide does not exist at a pressure of 1 atmosphere. The heat of vaporization of liquid carbon dioxide was measured by Chappuis^{1, 2} and Mathias.¹ Vapor pressure data on liquid carbon dioxide were reported by Faraday,³ Regnault,⁶ Mollier,¹ Amagat,^{1, 2, 3} Tate,² Balserna,¹ Cailletet,³ DuBois and Wills,¹ Verschaffelt,¹ Villard and Jarry,¹ Zeleny and Smith,¹ Antoine,² Jarolimek,^{1, 2, 3, 4} Andrews,¹⁷ Keyes and Kenney,¹ Kuenen and Robson,¹ Meyers and Van Dusen,¹ Scheffer,² von Siemens,¹ Stock, Henning, and Kuss,¹ Villard,¹ and Jenkins and Pye.^{1, 2}

CO₂ (c). Calorimetric data on the heat of sublimation of solid carbon dioxide were reported by Andrews,⁸ Favre and Silbermann,³ Behn,¹ and Eucken and Donath.¹ Vapor pressure data on solid carbon dioxide were reported by Faraday,³ Dubois and Wills,¹ Henning,³ Henning and Stock,¹ Kuenen and Robson,¹ Onnes and Weber,² von Siemens,¹ Stock, Henning, and Kuss,¹ Homfray,¹ Villard and Jarry,¹ and Zeleny and Smith.^{1, 2}

CO₂ (aq.). The calorimetric data on the heat of solution of CO₂ (g) in water are: Thomsen,¹⁵ 5.88₁₅₀₀; Berthelot,⁷ 5.6; Adolph and Henderson,¹ 4.69. The data on the solubility of carbon dioxide in water at various temperatures yield 4.76.

CO₂ · 6H₂O (c). The data of Villard^{2, 10} and Wroblewsky³ yield -8.3 for the heat of the reaction, CO₂ · 6H₂O (c) = CO₂ (aq.) + 6H₂O (liq.), at 0°.

CO₃⁻ (∞). The value for aqueous carbonate ion at infinite dilution is obtained from those for aqueous lithium, sodium, and potassium carbonates at infinite dilution.

CO₃⁻ (g). The lattice energy calculations of Lennard-Jones and Dent^{1, 2} on the carbonates of zinc, cadmium, calcium, and magnesium yield, for CO₃⁻ (g), $Q_f = -75 \pm 10$.

C₂O₄⁻ (aq.). The value for aqueous oxalate ion is obtained from those for aqueous sodium and potassium oxalates.

C₃O₂ (liq.). Vapor pressure data were reported by Stock and Stolzenberg.¹

CH (g). The value for the energy of dissociation of CH (g) into gaseous carbon and hydrogen atoms is obtained from the data of Mulliken,⁵ Kratzer,² Hori,⁴ and Villars.¹ The values for the energy states of CH (g) are from Mulliken.⁵

CH₃⁺ (g). The data of Hogness and Kvalnes¹ (see also Pietsch and Wilcke¹) yield a value for the energy of the reaction, CH₄ (g) = CH₃⁺ (g) + H (g) + θ .

CH₄ (g). The heat of combustion of methane was measured by Andrews,¹⁴ Favre and Silbermann,¹ Thomsen,¹⁵ Berthelot and Matignon,⁷ Roth and Banse,² and Rossini.^{2, 5} Mixer¹ made two experiments on the heat of decomposition of methane into carbon and hydrogen by exploding a mixture of acetylene, methane, and hydrogen in a bomb. The modern data yield the following values for the heat of the reaction, $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) = \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{liq.})$, at 18° and a constant pressure of 1 atmosphere: Roth and Banse,² 213.27 ± 0.64 ; Rossini,^{2, 5} 212.95 ± 0.07 .

CH₄⁺ (g). The value for the energy of ionization of CH₄ (g) is obtained from the data of Pietsch and Wilcke,¹ Glockler,¹ Morris,¹ Mayer,¹ Hughes and Klein,¹ and Pietsch.¹

CH₄ (liq.). Vapor pressure data on liquid methane were reported by Keyes, Taylor, and Smith,¹ Crommelin,⁶ Homfray,¹ and Stock, Henning, and Kuss.¹ See also Satterly and Patterson.¹

CH₄ (c). Vapor pressure data on solid methane were reported by Karwat¹ and Freeth and Verschoyle.¹ The calorimetric data on the heat of fusion are: Eucken and Karwat,¹ -0.23 at -182° ; Clusius,² -0.224 at -182.5° . Clusius² measured the heat of transition at -252.7° .

CH₄ · 6H₂O (c). The dissociation pressure data of Villard^{2, 10} yield -14.2 for the heat of the reaction, $\text{CH}_4 \cdot 6\text{H}_2\text{O}(\text{c}) = \text{CH}_4(\text{g}) + 6\text{H}_2\text{O}(\text{liq.})$.

C₂H₂ (g). The heat of combustion of acetylene was measured by Berthelot,⁷¹ Berthelot and Matignon,⁸ Thomsen,¹⁵ and Mixer.⁴ The data of the latter two investigations yield the following values for the heat of combustion of acetylene: Thomsen,¹⁵ 309.8 ± 1.5 ; Mixer,⁴ 312.5 ± 2.5 . Hence, for C₂H₂ (g), $Q_f = -52.5 \pm 1.5$ and -55.2 ± 2.5 , respectively. Mixer⁴ also measured the heat of decomposition of acetylene into "acetylene" carbon and hydrogen. His data yield for the reaction, $\text{C}_2\text{H}_2(\text{g}) = 2\text{C}$ ("amorphous," "acetylene" carbon) + H₂(g), $Q = 53.3 \pm 0.1$; whence, for C₂H₂ (g), $Q_f = -53.9 \pm 0.2$. See also Berthelot³² and Berner.³

C₂H₂ (liq.). Acetylene does not exist as a liquid at a pressure of 1 atmosphere. Vapor pressure data on liquid acetylene were obtained by McIntosh,¹ Cardoso and Baum,¹ Kuenen,² Villard,¹ Ansdell,² Ladenburg and Krugel,² Hunter,¹ and Cailletet.¹ McIntosh¹ reported a value for the heat of vaporization at the triple point, -81.5° .

C₂H₂ (c). Solid acetylene has a vapor pressure of 1 atmosphere at -84.0° . Vapor pressure data on solid acetylene were reported by McIntosh,¹ Cardoso and Baum,¹ Kuenen,² Villard,¹ Ansdell,² Ladenburg and Krugel,² Hunter,¹ and Cailletet.¹ McIntosh¹ reported a value for the heat of sublimation and the heat of fusion.

C₂H₂ (aq.). Villard⁷ reported the heat of solution of acetylene in water to be 5.3. The solubility-temperature data of Winkler⁵ yield 4.0.

C₂H₂ · 6H₂O (c). Villard⁶ determined the heats of the reactions $\text{C}_2\text{H}_2 \cdot 6\text{H}_2\text{O}(\text{c}) = \text{C}_2\text{H}_2(\text{aq.}) + 6\text{H}_2\text{O}(\text{liq.})$, and $\text{C}_2\text{H}_2 \cdot 6\text{H}_2\text{O}(\text{c}) = \text{C}_2\text{H}_2(\text{g}) + 6\text{H}_2\text{O}(\text{liq.})$, to be -10.1 and -15.4 , respectively, at 0°; whence, for C₂H₂ · 6H₂O (c), $Q_f = 370.6$ and 371.9 .

$(C_2H_2)_3$ (g). Sameshima and Fukaya¹ reported $Q = -3.03$ for the heat of dissociation of the polymer of acetylene, $(C_2H_2)_3$ (g) = $3C_2H_2$ (g).

C_2H_4 (g). The heat of combustion of ethylene was measured by Dulong,² Grassi,¹ Favre and Silbermann,¹ Andrews,¹⁴ Berthelot,⁷¹ Berthelot and Matignon,⁸ Thomsen,¹⁵ and Mixer.¹ The data of the last four named investigations yield the following values for the heat of the reaction, C_2H_4 (g) + $3O_2$ (g) = $2CO_2$ (g) + $2H_2O$ (liq.): Berthelot,⁷¹ 341.3 ± 2.2 ; Berthelot and Matignon,⁸ 341.2 ± 1.3 ; Thomsen,¹⁵ 333.1 ± 0.8 ; Mixer, 344.5 ± 2.3 . These values yield, for C_2H_4 (g), $Q_f = -15.7 \pm 2.2$, -15.6 ± 1.3 , -7.5 ± 0.8 , and -18.9 ± 2.3 , respectively. Mixer¹ also performed three experiments involving the explosion of a mixture acetylene and ethylene. His data yield for the reaction, C_2H_4 (g) = $2C$ ("amorphous," "acetylene" carbon) + $2H_2$ (g), $Q = -15.1 \pm 4.0$; whence, for C_2H_4 (g), $Q_f = -15.7 \pm 4.0$. von Wartenberg and Krause¹ measured the heat of hydrogenation of ethylene to form ethane. Their data yield $Q = 30.6 \pm 0.4$ for the reaction, C_2H_4 (g) + H_2 (g) = C_2H_6 (g); whence, for C_2H_4 (g), $Q_f = -9.6 \pm 0.4$.

C_2H_4 (liq.), C_2H_4 (c). Vapor pressure data were reported by Faraday,³ Dewar,² Cailletet,² Olszewski,^{6, 11} Witkowski,¹ Ladenburg and Krugel,¹ Hunter,¹ Villard,¹ Cardoso and Arni,¹ Burrell and Robertson,² Maass and Wright,¹ Henning and Stock,¹ and Britton.¹

$C_2H_4 \cdot 6H_2O$ (c). Villard⁶ reported $Q = -15.4$ for the reaction, $C_2H_4 \cdot 6H_2O$ (c) = C_2H_4 (g) + $6H_2O$ (liq.)

C_2H_6 (g). The heat of combustion of ethane was measured by Berthelot,⁷¹ Berthelot and Matignon,⁸ Thomsen,¹⁵ and Rossini.¹³ The last named investigator found for the reaction, C_2H_6 (g) + $3\frac{1}{2}O_2$ (g) = $2CO_2$ (g) + $3H_2O$ (liq.), $Q = 372.81 \pm 0.11$, at 25° and a constant pressure of 1 atmosphere. This value is equivalent to 373.05 ± 0.11 at 18° , whence, for C_2H_6 (g), $Q_f = 20.96 \pm 0.15$.

C_2H_6 (liq.). Wiebe, Hubbard, and Brevoort¹ measured the heat of vaporization of ethane. Vapor pressure data were reported by Porter,¹ Dana, Jenkins, Burdick, and Timms,¹ Loomis and Waters,¹ Prins,¹ Burrell and Robertson,² Maass and McIntosh,¹ Cardoso and Bell,¹¹ Cardoso,¹ Kuenen and Robson,¹ Kuenen,¹ Olszewski,^{2, 11} Hara and Shinozaki,¹ Ladenburg and Krugel,² and Dewar.²

C_2H_6 (c). Wiebe, Hubbard, and Brevoort¹ measured the heat of fusion of ethane.

CHO_2^- (aq.). The value for aqueous formate ion is obtained from those for aqueous sodium and potassium formates.

HCO_3^- (aq.). The values for aqueous bicarbonate ion, obtained from aqueous $LiHCO_3$, $NaHCO_3$, $KHCO_3$, and $RbHCO_3$, are 164.8, 164.9, 164.7, and 164.9, respectively. The equilibrium data of Kendall¹ and of Klemenc and Herzog¹ yield $Q = 2.89$ and 2.78 , respectively, for the reaction, H_2CO_3 (aq.) = H^+ (aq.) + HCO_3^- (aq.); whence, for HCO_3^- (aq.), $Q_f = 164.7$ and 164.8 , respectively.

HCHO (g). The data of von Wartenberg, Muchlinski, and Riedler¹ (see Kharasch¹) yield 134.1 for the heat of combustion of gaseous formaldehyde.

CH₃OH (g). The heat of combustion of gaseous methyl alcohol was measured by Thomsen¹⁵ and Rossini,^{9, 10} and of liquid methyl alcohol by Favre and Silbermann,¹ Stohmann, Kleber, and Langbein,⁴ Richards and Davis,¹ Roth and Müller,³ Roth and Banse,¹ and I. G. Farbenfabrik.¹ These data were reviewed by Rossini.¹⁰ For the heat for the reaction, $\text{CH}_3\text{OH (g)} + \frac{3}{2} \text{O}_2 \text{ (g)} = \text{CO}_2 \text{ (g)} + 2\text{H}_2\text{O (liq.)}$, at 25° and a constant total pressure of 1 atmosphere (the methyl alcohol being at a pressure slightly below saturation), Rossini¹⁶ gave the value 182.58 ± 0.05 . At 18°, this value becomes 182.75 ± 0.05 .

CH₃OH (liq.). Rossini¹⁶ reviewed the published data on the heat of vaporization of methyl alcohol and concluded that the best data are those of Fiock, Ginnings, and Holton.¹ Earlier calorimetric determinations on the heat of vaporization of methyl alcohol were reported by Brown,^{1, 2} Marshall,¹ Mathews,² Mills,¹ Tyrer,^{1, 2} Wirtz,¹ Young,² Jahn,⁴ and Schall.¹ Vapor pressure data on methyl alcohol were reported by Timmermans,¹ Young,² Richards and Shipley,¹ Mundel,¹ Richardson,¹ Tyrer,⁴ Drucker, Jimmens, and Kangro,¹ Atkins and Wallace,¹ Young and Fortey,¹ and Regnault.⁶

CH₃OH (c). Data on the heat of fusion of methyl alcohol were reported by the following: Kelley,¹ -0.76 at -98° ; Maass and Waldbauer,¹ -0.53 at -97° ; Parks,¹ -0.71 at -98° . See also Mitzukuri.¹ Parks¹ measured the heat of transition at -112° .

CH₃OH (aq.). Data on the heat of solution of methyl alcohol in water were reported by Berthelot,³⁶ deForcrand,^{6, 7} and Bose.^{1a} The latter's data also yield values for the heat of dilution of aqueous methyl alcohol.

CH₃O⁻ (CH₃OH). Wolfenden, Jackson, and Hartley¹ reported the heat of ionization of liquid methyl alcohol, in liquid methyl alcohol, to be -11.2 .

HCOOH (liq.). The heat of combustion of gaseous formic acid was measured by Favre and Silbermann¹ and Thomsen,¹⁵ and of liquid formic acid by Berthelot and Matignon,^{5, 10} and Jahn.² The data yield the following values for the heat of combustion of liquid formic acid: Thomsen,¹⁵ 63.0; Berthelot and Matignon,^{5, 10} 62.5; Jahn,² 63.0. Berthelot,^{25, 150} measured the heat of decomposition of formic acid with aqueous sulfuric acid.

HCOOH (g), (HCOOH)₂ (g). Ramsperger and Porter² and Coodlidge¹ studied the equilibrium, $(\text{HCOOH})_2 \text{ (g)} = 2\text{HCOOH (g)}$, and their data yield -14.13 for the heat of this reaction. The equilibrium concentrations in mole fraction are, for $(\text{HCOOH})_2 \text{ (g)}$ and HCOOH (g) , respectively, about 0.80 and 0.20 at 18°, and about 0.52 and 0.48 at the boiling point, 100.8°. Data on the heat of vaporization of liquid formic acid to form the equilibrium mixture of $(\text{HCOOH})_2 \text{ (g)}$ and HCOOH (g)

were reported by Ramsperger and Porter,^{1, 2} Marshall,¹ Ogier,⁵ and Favre and Silbermann.¹⁰ We have calculated $Q = -8.57$ for the reaction $2\text{HCOOH (liq.)} = (\text{HCOOH})_2 \text{ (g.)}$, at 18° .

HCOOH (c). The data on the heat of fusion of formic acid at its melting point are: Coolidge,¹ -3.05 ; Zanninovich-Tessarini,¹ -2.63 ; Tammann,³ -2.82 ; Petersen,^{3, 4} -2.68 ; Berthelot,²⁵ -2.40 ; Rideal,¹ -2.62 .

HCOOH (aq.). Data on the heat of solution and of dilution of formic acid in water were reported by Berthelot,²⁵ Faucon,¹ and Thomsen.¹⁵ Thomsen¹⁵ measured the heat of oxidation of aqueous formic acid with aqueous potassium permanganate, and his data yield, for HCOOH (aq.), $Q_f = 101.4$. See also Wrewskii and Stagleova,¹ who reported values for the heat of polymerization of formic acid in water (and also in benzene).

H₂CO₃ (aq.). This is taken as equivalent to $\text{CO}_2 \text{ (aq.)} + \text{H}_2\text{O (liq.)}$.

HC₂O₄⁻ (aq.). The value for aqueous bioxalate ion is obtained from $\text{NaHC}_2\text{O}_4 \text{ (aq.)}$.

(COOH)₂ (c). The heat of combustion of crystalline oxalic acid was measured by Stohmann, Kleber, and Langbein,¹ Jahn,² and Verkade, Hartman, and Coops.² The data of the last named investigation were reviewed by Washburn,² who showed that the correction to a pressure of 1 atmosphere (from the conditions of the bomb process) is -0.66 per cent. With the Washburn correction to 1 atmosphere, the data of Verkade, Hartman, and Coops² yield 59.7 for the heat of the reaction, $(\text{COOH})_2 \text{ (c)} + \frac{1}{2} \text{O}_2 \text{ (g)} = 2\text{CO}_2 \text{ (g)} + \text{H}_2\text{O (liq.)}$ at 18° and a constant pressure of 1 atmosphere.

(COOH)₂ (g). Vapor pressure data on crystalline oxalic acid were reported by Noyes and Webbe.¹

(COOH)₂ (aq.). Thomsen¹⁵ and Berthelot^{10, 25} measured the heat of solution of oxalic acid. With Thomsen's value $S = -2.26_{200}$, we have computed, for $(\text{COOH})_2 \text{ (aq.)}$, $Q_f = 195.3$. Thomsen's¹⁵ data on the reaction of aqueous hypochlorous acid with aqueous oxalic acid yield, for $(\text{COOH})_2 \text{ (aq.)}$, $Q_f = 194.5$. Berthelot's²⁵ data on the reaction of gaseous chlorine with aqueous oxalic acid yield, for $(\text{COOH})_2 \text{ (aq.)}$, $Q_f = 194.8$. Berthelot's²⁵ data on the reaction of aqueous potassium permanganate with aqueous oxalic acid yield, for $(\text{COOH})_2 \text{ (aq.)}$, $Q_f = 195.5$.

(COOH)₂ · 2H₂O (c). The heat of solution of oxalic acid dihydrate was measured by Thomsen,¹⁵ Favre and Silbermann,³ Berthelot,¹⁰ Graham,³ Jorissen,² Jorissen and van der Stadt,¹ and Roth and Eymann.¹ Jorissen and van der Stadt¹ measured the heat of combustion. Timofejew¹ measured the heat of solution in methyl and ethyl alcohols.

C₂H₃O₂⁻ (∞). The value for aqueous acetate ion at infinite dilution is obtained from that for aqueous sodium acetate at infinite dilution.

C₂H₃O₃⁻ (aq.). The value for aqueous glycolate ion is obtained from those for the aqueous salts.

(CHO)₂ (c). Estimating the Washburn² correction to be -0.15 per cent, we have computed from the data of deForcrand³ (see Kharasch¹) the heat of combustion of glyoxal to be 172.0.

(CHO)₂ (aq.). deForcrand³ measured the heat of solution of glyoxal.

(CHO)₂ (g). We have estimated the heat of sublimation of glyoxal.

(HO)₂CHCOOH (c). Berthelot and Matignon⁶ (see Kharasch¹) measured the heat of combustion of glyoxylic acid. Estimating the Washburn² correction to be -0.25 per cent, we have calculated the heat of combustion to be 125.2.

(HO)₂CHCOOH (aq.). deForcrand¹⁷ measured the heat of solution of glyoxylic acid.

CH₃CHO (g). The heat of combustion of gaseous acetaldehyde was measured by Thomsen¹⁵ and Berthelot and Ogier,² and of liquid acetaldehyde by Berthelot and Delepine⁴ and Louguinine.²⁵ Thomsen's¹⁵ data yield 281.6 for the heat of combustion of the gas.

CH₃CHO (liq.). Berthelot³³ measured the heat of vaporization of acetaldehyde to be -6.02 at 22°. The vapor pressure data of Gilmour¹ yield -6.6 at 22°.

CH₃CHO (c). Cooper¹ measured the heat of fusion of acetaldehyde.

C₂H₄O (g). Thomsen's¹⁵ data yield 312.3 for the heat of combustion of ethylene oxide in the gaseous state; those of Berthelot⁸¹ yield the value 308.4.

C₂H₄O (liq.). Berthelot⁸¹ reported a value for the heat of vaporization of ethylene oxide. Vapor pressure data were reported by Everheim.¹

CH₃COOH (liq.). The heat of combustion of liquid acetic acid was measured by Berthelot and Matignon³ and Roth,² and of gaseous acetic acid by Thomsen.¹⁵ Applying a Washburn correction of -0.10 per cent, we have computed Roth's² value to be 206.7 for the heat of combustion of the liquid, and that of Berthelot and Matignon³ to be 209.2. Thomsen's¹⁵ data yield 227.4 for the heat of reaction of gaseous acetic acid at 111° with oxygen at 18° to form gaseous carbon dioxide and liquid water at 18°.

CH₃COOH (c). Louguinine and Dupont,¹ Parks and Kelley,¹ Berthelot,³ Petterson,^{1, 4} Bridgman,⁷ Raoult,¹ Garner, Madden, and Rushbroke,¹ and Pickering¹⁰ determined the heat of fusion of acetic acid.

CH₃COOH (aq.). The heat of solution of solid acetic acid in water was measured by Berthelot,^{3, 9} and Petterson,¹ and of liquid acetic acid in water by Berthelot,^{3, 9} and Berthelot and Louguinine.¹ Data on the heat of dilution of aqueous acetic acid were reported by Thomsen,¹⁵ Berthelot and Louguinine,¹ Berthelot,^{3, 9} Faucon,¹ Payn and Perman,¹ Bose,¹ and Richards and Gucker.¹ We have extrapolated the data of Richards and Gucker¹ to infinite dilution to obtain a value for aqueous undissociated CH₃COOH at infinite dilution in water.

HCOOCH₃ (g). Thomsen¹⁵ and Berthelot and Ogier³ measured the heat of combustion of gaseous methyl formate, and Berthelot and Dele-

pine⁴ that of liquid methyl formate. Their data yield for the heat of combustion of the gas, 241.0, 240.2, and 240.9, respectively.

HCOOCH₃ (liq.). The heat of vaporization of methyl formate was measured by Mathews² and Berthelot and Ogier,³ who reported the values 6.75 and 6.9, respectively, at 31°. Vapor pressure data were reported by Olszewski² and Pierre.¹

HCOOCH₃ (c). Rideal¹ computed the heat of fusion of methyl formate.

C₂H₅OH (g). The heat of combustion of ethyl alcohol was measured by Andrews,^{5, 14} Favre and Silbermann,¹ Berthelot and Matignon,⁵ Atwater and Rosa,¹ Atwater and Snell,¹ Emory and Benedict,¹ Roth and Müller,³ Richards and Davis,¹ and Rossini.¹⁰ These data were reviewed by Rossini¹⁰ whose own experiments on the heat of combustion of gaseous ethyl alcohol at 32.50° yield (see Rossini¹⁶) for the heat of the reaction, C₂H₅OH (g) + 3 O₂ (g) = 2CO₂ (g) + 3H₂O (liq.), $Q = 336.78 \pm 0.10$ at 25° and a constant total pressure of 1 atmosphere. This value becomes 337.06 ± 0.10 at 18°.

C₂H₅OH (liq.). The heat of vaporization of ethyl alcohol was measured by Brown,^{1, 2} Marshall and Ramsay,¹ Louguinine,¹¹ Mathews,² Mills,¹ Tyrer,¹ Wirtz,¹ Young,² Jahn,⁴ Regnault,^{6, 9} Schall,¹ Andrews,⁶ Parks and Nelson,¹ Svensson,¹ and Fiock, Ginnings and Holton.¹ See Rossini.¹⁶

C₂H₅OH (c). The heat of fusion of ethyl alcohol was measured by Gibson, Parks, and Latimer¹ and Parks.¹ See also Mitsukuri¹ and Mitsukuri and Hara.²

C₂H₅OH (aq.). The heat of mixing alcohol with water was measured by Berthelot,³⁶ Bose,¹ Dupre and Page,¹ MacInnis and Braham,¹ Pratt,¹ de Forcrand,²² Winkelmann,⁴ and Kolosovskii.¹

C₂H₅O⁻ (aq.). van Deventer and Cohen¹ measured the heat of neutralization of NaOC₂H₅ in ethyl alcohol with HCl in ethyl alcohol.

CH₂OHCOOH (c). Stohmann, Kleber, Langbein, and Offenhauer,^{1, 2} (see Kharasch¹) measured the heat of combustion of solid glycollic acid.

CH₂OHCOOH (aq.). de Forcrand³ measured the heat of solution of solid glycollic acid in water.

(CH₃)₂O (g). The heat of combustion of gaseous dimethyl ether was measured by Thomsen¹⁵ and Berthelot.⁷¹ See also Berner.⁴ Thomsen's¹⁵ data yield 349.0 for the heat of combustion of the gas.

(CH₃)₂O (liq.). Vapor pressure data were reported by Cardoso and Bruni¹ and Regnault.⁷

(CH₂OH)₂ (liq.). Stohman and Langbein³ and Louguinine² measured the heat of combustion of ethylene glycol (see Kharasch¹).

(CH₂OH)₂ (g). Vapor pressure data on ethylene glycol were reported by de Forcrand.³³ Louguinine² measured the heat of condensation. These data yield $V = -14.3$ and -11.8 , respectively.

CF₄ (g). von Wartenberg and Schütte¹ measured the heat of the reaction, C (charcoal) + 2 F₂ (g) = CF₄ (g), to be 165.0 ± 2.0 .

CH₂FCH₂OH (liq.). Swarts^{4, 5} (see Kharasch¹) measured the heat of combustion of monofluoroethanol.

CHF₂CH₂OH (liq.). Swarts^{4, 5} (see Kharasch¹) measured the heat of combustion of difluoroethanol.

CH₂FCOOH (c). Swarts⁴ (see Kharasch¹) measured the heat of combustion of monofluoroacetic acid.

CHF₂COOH (liq.). Swarts⁴ (see Kharasch¹) measured the heat of combustion of difluoroacetic acid.

CCl₄ (g). Bodenstein, Gunther, and Hoffmeister¹ measured the heat of the reaction, CCl₄ (g) + 2 H₂ (g) = C ("acetylene" carbon) + 4 HCl (g), to be 62.0; whence, for CCl₄ (g), $Q_f = 25.9$. Berthelot¹⁰⁸ and Thomsen¹⁵ measured the heat of combustion of carbon tetrachloride.

CCl₄ (liq.). Data on the heat of vaporization of carbon tetrachloride were reported by Marshall,¹ Mathews,² Mills,¹ Tyrer,³ and Regnault.^{8, 9} Vapor pressure data were reported by Young,² Burrell and Robertson,² Cardoso and Braume,² Guye and Drouguinine,¹ Keyes, Taylor, and Smith,¹ Olszewski,^{2, 4} and Pierre.¹

CCl₄ (c). The data on the heat of fusion of CCl₄ (c, I) are: Latimer,¹ -0.69 at -24° ; Bridgman,² -0.55 at -23° . Latimer¹ measured the heat of transition.

C₂Cl₆ (c). Berthelot¹⁰⁸ measured the heat of combustion of solid hexachloroethane, but his value of 110.0 (see Kharasch¹) is much too low. The vapor pressure data of Nelson¹ yield -17.0 for the heat of sublimation.

C₂Cl₆ (g). We have estimated this value.

C₂Cl₄ (g). Thomsen¹⁵ measured the heat of combustion of gaseous tetrachloroethylene, and his data yield $Q_f = -6.0$.

C₂Cl₄ (liq.). Berthelot¹⁰⁸ reported a value for the heat of combustion of liquid tetrachloroethylene, but his value must be too low. Mathews² reported the heat of vaporization to be -8.27 at 120° ; the vapor pressure data of Herz and Rathmann¹ yield -8.4 .

COCl₂ (g). Thomsen's¹⁵ data on the heat of combustion of gaseous phosgene yield $Q_f = 52.7$. Thomsen¹⁵ and Berthelot⁵¹ measured the heat of reaction of gaseous phosgene with aqueous potassium hydroxide, and their data yield, for COCl₂ (g), $Q_f = 54.4$ and 60.6 , respectively. The equilibrium data of Bodenstein and Plant,¹ Bodenstein and Danant,¹ Atkinson, Heycock, and Pope,¹ Christiansen,¹ and Weigert¹ on the reaction, CO (g) + Cl₂ (g) = COCl₂ (g), yield, for COCl₂ (g), $Q_f = 53.5$.

COCl₂ (liq.). Vapor pressure data were reported by Atkinson, Heycock, and Pope,¹ Nikiten,² Paterno and Mazzuchelli,¹ Perry and Porter,¹ and Germann and Taylor.¹

CH₃Cl (g). Thomsen¹⁵ and Berthelot⁷⁰ measured the heat of combustion of methyl chloride. Thomsen's¹⁵ data yield $Q_f = 20.1$.

CH₃Cl (liq.). The heat of vaporization was measured by Chappuis,³ Shorthose,¹ Yates,¹ and Regnault.⁹ Vapor pressure data were reported by Holts,² Shorthose,¹ and Regnault.^{6, 7}

$\text{C}_2\text{H}_2\text{Cl}_2$ (liq.). Berthelot and Ogier¹ measured the heat of combustion.

$\text{C}_2\text{H}_2\text{Cl}_2$ (g). Mathews² found the heat of vaporization to be -6.69 at 40° . Vapor pressure data were reported by Korber,¹ Nilson and Peterson,¹ and Perry.¹

CHCl_3 (g). The heat of combustion of chloroform was measured by Thomsen,¹⁵ Berthelot,¹⁰⁸ and Berthelot and Matignon.^{5a} Thomsen's¹⁵ data yield, for CHCl_3 (g), $Q_f = 21.7$. We have estimated 23.6.

CHCl_3 (liq.). Data on the heat of vaporization of chloroform were reported by Regnault,^{8,9} Marshall,¹ Mathews,² Mills,¹ Tyrer,³ and Wirtz.¹

CHCl_3 (c). Mitsukuri and Aoki¹ reported a value for the heat of fusion.

CHCl_3 (aq.). Berthelot⁴³ measured the heat of solution of chloroform in water.

$\text{C}_2\text{H}_3\text{Cl}$ (g). Thomsen's¹⁵ data on the heat of combustion yield, for monochlorethylene, or vinyl chloride, $Q_f = -6.5$. We have estimated $Q_f = -9$.

$\text{C}_2\text{H}_3\text{Cl}$ (liq.). Vapor pressure data were reported by Dana, Burdick, and Jenkins.¹

$\text{C}_2\text{H}_5\text{Cl}$ (g). Thomsen¹⁵ and Berthelot¹⁰⁸ measured the heat of combustion of ethyl chloride. The data of the former yield $Q_f = 25.7$.

$\text{C}_2\text{H}_5\text{Cl}$ (liq.). Yates¹ and Regnault⁶ measured the heat of vaporization. Vapor pressure data were reported by Berthoud,¹ Jenkins and Shorthose,¹ Regnault,⁶ and Antoine.³

$\text{CH}_2\text{ClCH}_2\text{Cl}$ (g). Thomsen¹⁵ measured the heat of combustion of ethylene chloride.

$\text{CH}_2\text{ClCH}_2\text{Cl}$ (liq.). The heat of vaporization of ethylene chloride was measured by Jahn⁴ and Mathews.² Vapor pressure data were reported by Pearce and Peters,¹ Rex,¹ Stadel,¹ and Timmermans.¹

CH_3CHCl_2 (g). Data on the heat of combustion of ethylidene chloride were reported by Thomsen¹⁵ and Berthelot and Ogier.³

CH_3CHCl_2 (liq.). Vapor pressure data were reported by Reilly and Hickinbottom¹ and Stadel.¹

$\text{CHCl}_2\text{CHCl}_2$ (g). We have estimated the heat of formation of symmetrical tetrachloroethane.

$\text{CHCl}_2\text{CHCl}_2$ (liq.). Vapor pressure data were obtained by Nelson.¹

$\text{CHCl}_2\text{CCl}_3$ (g). We have estimated the value for pentachloroethane.

$\text{CHCl}_2\text{CCl}_3$ (liq.). Vapor pressure data were obtained by Nelson.¹

CH_2ClCHO (liq.). Rivals^{1,2} measured the heat of combustion of monochloroacetaldehyde.

CH_3COCl (liq.). Berthelot and Louguinine¹ measured the heat of reaction of liquid acetyl chloride with water to be 23.3. See also Rivals.^{1,5}

CH_3COCl (g). Berthelot and Ogier⁸ measured the heat of vaporization of acetyl chloride.

CH_2ClCOCl (liq.). Rivals^{1, 2} measured the heat of reaction of liquid monochloroacetyl chloride with aqueous potassium hydroxide.

Cl_3CCHO (aq.). Berthelot^{43, 60} measured the heat of the reaction, Cl_3CCHO (aq.) + KOH (aq.) = ($\text{KCHO}_2 + \text{CHCl}_3$) (aq.), to be 13.15; whence, for aqueous chloral, $Q_f = 65.4$.

Cl_3CCHO (liq.). Berthelot^{43, 60} measured the heat of solution of liquid chloral in water.

Cl_3CCHO (g.). Berthelot^{43, 60} determined the heat of vaporization of liquid chloral.

$\text{Cl}_3\text{CCH}(\text{OH})_2$ (g.). Berthelot^{43, 60} measured the heat of solution of gaseous chloral hydrate.

$\text{Cl}_3\text{CCH}(\text{OH})_2$ (c, II). Berthelot^{43, 60} measured the heat of solution of this solid form of chloral hydrate.

$\text{Cl}_3\text{CCH}(\text{OH})_2$ (liq.). Berthelot reported the heat of fusion of chloral hydrate (c, II).

$\text{Cl}_3\text{CCH}(\text{OH})_2$ (c, I). Berthelot^{43, 60} measured the heat of fusion.

CH_2ClCOOH (c, α). Berthelot and Matignon⁷ measured the heat of combustion of monochloroacetic acid (c, α).

CH_2ClCOOH (liq.). The data on the heat of fusion of monochloroacetic acid (c, α) at 61° are: Pickering,¹⁰ -3.90; Steiner and Johnston,¹ -4.63. See also Tanatar⁴ and Louguinine.¹

CH_2ClCOOH (c, β). The data on the heat of fusion of monochloroacetic acid (c, β) at 56° are: Pickering,¹⁰ -3.33; Steiner and Johnston,¹ -4.45. See also Tanatar⁴ and Louguinine.¹

CH_2ClCOOH (c, γ). Steiner and Johnston¹ measured the heat of fusion of monochloroacetic acid (c, γ). See also Tanatar⁴ and Louguinine.¹

CH_2ClCOOH (aq.). For the heat of solution of monochloroacetic acid (c, α) in water, Pickering¹⁰ found -3.35 and Louguinine -2.33.

CH_2ClCOOH (g.). Vapor pressure data were reported by Patterson.¹

$\text{CH}_2\text{ClCOO}^-$ (aq.). The value for aqueous monochloroacetate ion is obtained from that for the aqueous sodium salt.

CCl_3COOH (c). Berthelot and Matignon⁷ measured the heat of combustion of trichloroacetic acid.

CCl_3COOH (liq.). Pickering¹⁰ measured the heat of fusion.

CCl_3COOH (aq.). Pickering¹⁰ and Louguinine¹ found the heat of solution of solid trichloroacetic acid in water to be 2.70₄₀₀¹⁵ and 2.89₁₀₀, respectively.

CHCl_2COOH (aq.). We have estimated the value for the heat of formation of aqueous dichloroacetic acid.

CHCl_2COOH (liq.). Louguinine¹ and Pickering¹⁰ measured the heat of solution of liquid dichloroacetic acid.

CHCl_2COOH (c). Pickering¹⁰ measured the heat of fusion of dichloroacetic acid.

CHCl_2COOH (g.). Louguinine¹ measured the heat of vaporization.

$\text{CH}_2\text{ClCH}_2\text{OH}$ (liq.). Berthelot⁶² reported $Q = 36.0$ for the reaction

of gaseous ethylene oxide with gaseous hydrogen chloride to form liquid monochloroethanol.

COBr₂ (g). Trautz⁸ studied the equilibrium, $\text{CO (g)} + \text{Br}_2 \text{ (g)} = \text{COBr}_2 \text{ (g)}$, and computed $Q = 3.14$; whence, for $\text{COBr}_2 \text{ (g)}$, $Q_f = 22.3$.

CH₃Br (g). Thomsen¹⁵ and Berthelot^{70, 116} measured the heat of combustion. Thomsen's¹⁵ data yield $Q_f = 8.5$.

C₂H₅Br (g). Thomsen¹⁵ measured the heat of combustion of gaseous ethyl bromide.

C₂H₅Br (liq.). The heat of vaporization was measured by Tyrer,² Marshall,¹ and Berthelot.^{53, 87} Vapor pressure data were reported by Regnault,^{6, 7} Rex,¹ Richards and Mathews,¹ Timmermans,¹ and Tyrer.¹

CH₂BrCH₂Br (liq.). Berthelot³⁴ found $Q = 29.3$ for the reaction, $\text{C}_2\text{H}_4 \text{ (g)} + \text{Br}_2 \text{ (liq.)} = \text{CH}_2\text{BrCH}_2\text{Br (liq.)}$; whence, for liquid symmetrical dibromoethane, $Q_f = 19.7$.

CH₂BrCH₂Br (g). Vapor pressure data were reported by Regnault⁶ and Timmermans.² Berthelot⁵³ reported $V = -8.2$. Antoine³ calculated $V = -9.1$.

CH₃OH · HBr (c). McIntosh² reported values for the heat of fusion and the heat of dissociation, at -83° .

CHBr₃ (g). We have estimated the value for gaseous bromoform.

CH₂Br₂ (g). We have estimated the value for gaseous dibromomethane.

CBr₄ (g). We have estimated the value for gaseous carbon tetrabromide.

CH₃COBr (liq.). Berthelot and Louguinine¹ measured the heat of reaction of liquid acetyl bromide with water.

Br₃CCH(OH)₂ (c, I). Bruner² measured the heat of solution of bromal hydrate (c, I) (old crystallized material) in aqueous KOH.

Br₃CCH(OH)₂ (c, II). Bruner² measured the heat of solution of bromal hydrate (c, II) (freshly crystallized material) in aqueous KOH.

Br₃CCH(OH)₂ (aq.). Bruner² measured the heat of solution of bromal hydrate in water.

CH₂BrCOOH (c). Pickering¹⁰ measured the heat of solution of monobromoacetic acid.

CHBr₂COOH (c). Pickering¹⁰ measured the heat of solution of dibromoacetic acid.

CBBr₃COOH (c). Pickering¹⁰ measured the heat of solution of tribromoacetic acid.

C₂I₄ (c). Berthelot¹²¹ measured the heat of combustion of tetraiodoethylene.

CH₃I (g). Thomsen¹⁵ and Berthelot¹²¹ measured the heat of combustion of gaseous methyl iodide.

CH₃I (liq.). Marshall¹ measured the heat of vaporization. Vapor pressure data were reported by Brown and Acree,¹ Rex,¹ and Robertson and Acree.¹

CH₂I₂ (liq.). Berthelot¹²¹ measured the heat of combustion.

CH_2I_2 (g). We have estimated the value for diiodomethane.

CHI_3 (c). Berthelot¹²¹ measured the heat of combustion.

CHI_3 (g). We have estimated the value for gaseous iodoform.

$\text{C}_2\text{H}_5\text{I}$ (g). Thomsen¹⁵ measured the heat of combustion of ethyl iodide.

$\text{C}_2\text{H}_5\text{I}$ (liq.). Data on the heat of vaporization were reported by Mathews,² Marshall,¹ Regnault⁶ and Andrews.¹⁰ Vapor pressure data were reported by Regnault,⁷ Rex,¹ Robertson and Acree,¹ Thorpe and Rodger,¹ and Tyrer.⁴

$\text{CH}_2\text{ICH}_2\text{I}$ (c). Berthelot¹²¹ measured the heat of combustion of ethylene iodide.

$\text{CH}_2\text{ICH}_2\text{I}$ (g). We have estimated this value.

CH_3COI (liq.). Berthelot and Louguinine¹ measured the heat of reaction of acetyl iodide with water.

$\text{CH}_2\text{ICH}_2\text{Br}$ (c). Berthelot⁷⁴ measured the heat of the reaction, $\text{CH}_2\text{ICH}_2\text{I}$ (c) + Br_2 (liq.) = $\text{CH}_2\text{ICH}_2\text{Br}$ (c) + IBr (liq.), to be 13.9.

(CS)_x (c). Dewar² measured the heat of combustion of solid polymerized carbon monosulfide.

CS (g). We have estimated this value

CS₂ (g). Thomsen¹⁵ measured the heat of combustion of gaseous carbon disulfide, and Berthelot^{73, 108} that of the liquid. For CS₂ (g), Thomsen's¹⁵ data yield $Q_f = -28.6$, and those of Berthelot -17.0 and -24.4 , respectively. The equilibrium data of Koref² yield -16.7 .

CS₂ (liq.). Data on the heat of vaporization were reported by Mathews,² Mills,¹ Wirtz,¹ Winkelmann,^{2, 3} Koref,¹ Andrews,⁵ and Person.⁷ Vapor pressure data were reported by Battelli,¹ Henning and Stock,¹ Mund,¹ Regnault,^{6, 7} von Siemens,¹ Rex,¹ Stock and Seelig,¹ Galitzine,¹ Hannay,¹ and Muller and Grottrian.¹

CS₂ (c). Mitsukuri and Aoki¹ reported a value for the heat of fusion.

COS (g). Thomsen's¹⁵ data on the heat of combustion of gaseous carbonylsulfide yield, for COS (g), $Q_f = 34.5$. This value is in accord with the estimate of Lewis and Lacey¹ and with the equilibrium data of Stock, Sieke, and Pohland.¹ Berthelot's⁵¹ data on the heat of combustion are in disagreement with the foregoing data. From spectroscopic data, Lockte, Holtgreven, and Bawn¹ computed the energy of dissociation of COS (g) into CO (g) and S (g), and their data yield, for COS (g), $Q_f = 35$.

COS (liq.). Vapor pressure data were reported by Stock and Kuss.¹

CH₃SH (g). Thomsen¹⁵ reported the heat of combustion of gaseous methyl mercaptan.

CH₃SH (liq.). Vapor pressure data were reported by Berthoud and Brun.¹

(CH₃)₂S (g). Thomsen¹⁵ measured the heat of combustion of gaseous dimethyl sulfide.

(CH₃)₂S (liq.). Vapor pressure data were reported by Berthoud and Brun.¹

C₂H₅SH (g). The heat of combustion data of Thomsen¹⁵ and Berthelot^{124, 125} yield, for gaseous ethyl mercaptan, $Q_f = 9.7$ and 19 , respectively.

C₂H₅SH (liq.). Vapor pressure data were reported by Berthoud and Brun.¹

C₂H₅HSO₄ (aq.). Berthelot³⁶ reported the heat of reaction of aqueous ethanol with aqueous sulfuric acid. His data yield, for aqueous ethyl-sulfuric acid, $Q_f = 208.2$, which value seems too low.

C₂N₂ (g). For the heat of the reaction, $\text{C}_2\text{N}_2(\text{g}) + 2 \text{O}_2(\text{g}) = 2 \text{CO}_2(\text{g}) + \text{N}_2(\text{g})$, the various data are: Thomsen,¹⁵ 259.4 ; Berner,⁴ 262.1 ; Berthelot,⁵⁴ 264 ; Dulong,² 275 ; von Wartenberg and Schutza,¹ 261.3 ; McMorris and Badger,¹ 251.4 .

C₂N₂ (liq.). Vapor pressure data were reported by Faraday,³ Terwen,¹ Perry and Bardwell,¹ Chappuis and Riviere,¹ Cardoso and Braume,¹ Dewar,² and Bunsen.²

C₂N₂ (aq.). Cyanogen is slowly hydrolyzed in contact with water. The data of Berthelot¹²⁹ and Hammerl² on the heat of solution of gaseous cyanogen in water yield, when extrapolated to zero time, $S = 8.8$ and 6.8 , respectively.

NCN₃ (c). Darzen¹ measured the heat of decomposition of carbon perazuride.

HCN (g). The data on the heat of combustion are: Thomsen,¹⁵ 158.5 ; Berthelot,⁷⁶ 159.3 .

HCN (liq.). Berthelot's²⁷ data on the reaction, $\text{HCN}(\text{liq.}) + 2 \text{H}_2\text{O}(\text{liq.}) + \text{HCl}(\text{aq.}) = (\text{NH}_4\text{Cl} + \text{HCHO}_2)(\text{aq.})$, yield, for $\text{HCN}(\text{liq.})$, $Q_f = -16.2$. Berthelot²⁷ measured the heat of vaporization of liquid HCN to be -5.7 at the boiling point. The following values, computed from vapor pressure data, were reported for the heat of vaporization at 25° : Bredig and Teichmann,¹ -6.74 ; Hara and Sinozaki,¹ -6.6 ; Sinozaki, Hara, and Mitsukuri,¹ -6.67 ; Perry and Porter,¹ -6.65 ; Bussy and Brugnet,¹ -6.7 .

HCN (c). The data on the heat of fusion at -14° are: Sinozaki, Hara, and Mitsukuri,¹ -1.72 ; Perry and Porter,¹ -1.73 ; Piloty and Steinbock,¹ -1.68 .

HCN (aq.). Data on the heat of solution of $\text{HCN}(\text{liq.})$ were reported by Berthelot²⁷ and Bussy and Brugnet.¹

CN⁻ (aq.). The values for aqueous lithium, sodium, and potassium cyanides yield, for $\text{CN}^-(\text{aq.})$, $Q_f = -35.0$, -34.9 , and -34.8 , respectively. von Steinwehr's¹ conductivity data yield $Q = -11.0$ for the reaction, $\text{HCN}(\text{aq.}) = \text{H}^+(\text{aq.}) + \text{CN}^-(\text{aq.})$; whence, for $\text{CN}^-(\text{aq.})$, $Q_f = -34.9$.

CN (g). The energy of dissociation into gaseous atoms was reported by Birge and Sponer.¹ The values for the energy states of gaseous CN are from Mulliken,⁶ Jenkins,¹ Kratjer,¹ Ryde and Asundi,¹ Herzberg,² Heitler and Herzberg,¹ Turner and Samson,¹ and Weizel.¹

CN⁻ (g). Lederle² calculated the energy of the reaction, $\text{CN}(\text{g}) + \theta = \text{CN}^-(\text{g})$, to be 92 , from spectroscopic data on cyanonitrite. From the

lattice energies of KCN and NaCN, Sherman¹ computed the values 110.5 and 112.5 for the electron affinity of CN (g).

CNO⁻ (aq.). This value is obtained from those for the aqueous salts.

CH₃NH₂ (g). For the heat of combustion of gaseous methylamine, Thomsen¹⁵ found 258.1 and Muller⁴ 261.4. See also Lemoult.²

CH₃NH₂ (liq.). Gautier (see Berthelot¹⁵¹) measured the heat of vaporization to be -6.57. The vapor pressure data of Berthoud,¹ Felsing and Thomas,¹ and Plank and Vahl¹ yield -6.40 at -7°.

CH₃NH₂ (aq.). Data on the heat of solution of gaseous methylamine in water were obtained by Bonnifoi³ and Felsing and Wohlford.¹

CH₃NH₂·HCl (aq.). Muller^{1, 6} measured the heat of reaction of aqueous methylamine with aqueous HCl to be 13.0.

CH₃NH₃⁺ (aq.). The value for aqueous methylaminium ion is obtained from aqueous methylamine hydrochloride.

CH₃CN (g). Thomsen¹⁵ and Lemoult,¹ respectively, measured the heats of combustion of gaseous and of liquid acetonitrile, methylcyanide. Their data yield, for CH₃CN (g), $Q_f = -20.3$ and -17.9 , respectively.

CH₃CN (liq.). Kahlenberg¹ reported a value for the heat of vaporization.

NH₂CN (c). Lemoult^{1, 6} measured the heat of combustion of solid cyanamide.

NH₂CN (aq.). Lemoult^{1, 6} measured the heat of solution of solid cyanamide in water.

NH₂CN (liq.). Pratolongo¹ measured the heat of fusion.

NH₄CN (aq.). Berthelot²⁷ measured the heat of reaction of NH₄OH (aq.) with HCN (aq.) to be 1.3.

NH₄CN (c). Berthelot²⁷ measured the heat of solution of ammonium cyanide.

CH₃NC (liq.). The data on the heat of combustion (see Kharasch¹) of liquid methylisocyanide are: Lemoult,⁹ 317.4; Guillemard,¹ 320.1.

C₂H₅NH₂ (g). Thomsen's¹⁵ data on the heat of combustion of the gas yield, for gaseous ethylamine, $Q_f = 13.0$; those of Lemoult² on the heat of combustion of the liquid yield $Q_f = 13.3$. See also Berthelot.⁷⁵

C₂H₅NH₂ (liq.). Gautier (see Berthelot¹⁰²) measured the heat of vaporization to be -6.5 at 15°. The vapor pressure data of Berthoud¹ and Pohland and Mehl¹ yield -6.75 and -6.53 at 15°

C₂H₅NH₂ (aq.). Data on the heat of solution of liquid ethylamine were reported by Baud, Ducelliez, and Gay,¹ Berthelot,⁷⁵ and Colson.¹

C₂H₅NH₂·HCl (aq.). Thomsen¹⁵ measured the heat of reaction of aqueous ethylamine with aqueous HCl to be 13.44₄₀₀.

C₂H₅NH₂·HCl (c). Gautier² (see Berthelot¹⁵¹) measured the heat of solution of crystalline ethylamine hydrochloride.

C₂H₅NH₂·H⁺ (aq.). The value for aqueous ethylaminium ion is obtained from aqueous ethylamine hydrochloride.

(CH₃)₂NH (g). Thomsen¹⁵ and Muller⁴ measured the heat of com-

bustion of gaseous dimethylamine: Lemoult² that of the liquid. Their data yield, for $(\text{CH}_3)_2\text{NH}$ (g), $Q_f = 8.2, 2.0$, and 5.0 , respectively.

$(\text{CH}_3)_2\text{NH}$ (liq.). Vapor pressure data were reported by Berthoud.¹

$(\text{CH}_3)_2\text{NH}$ (aq.). We have estimated the heat of solution of dimethylamine.

$(\text{CH}_3)_2\text{NH} \cdot \text{HCl}$ (aq.). Thomsen measured the heat of reaction of $(\text{CH}_3)_2\text{NH}$ (aq.) with HCl (aq.) to be 11.81_{400} .

$(\text{CH}_3)_2\text{NH} \cdot \text{H}^+$ (aq.). The value for aqueous dimethylaminium ion is obtained from that for aqueous dimethylamine hydrochloride.

$\text{H}_2\text{NC}(:\text{NH})\text{NHCN}$ (c). Lemoult¹ measured the heat of combustion of dicyandiamide.

$\text{H}_2\text{NC}(:\text{NH})\text{NHCN}$ (aq.). Lemoult¹ measured the heat of solution of dicyandiamide.

NH_4CNO (c). The equilibrium data of Walker and Wood¹ yield 4.9 for the heat of the reaction, NH_4CNO (c) = $(\text{NH}_2)_2\text{CO}$ (c); whence, for NH_4CNO (c), $Q_f = 73.6$.

NH_4CNO (aq.). Walker and Wood¹ measured the heat of solution of solid ammonium cyanate in water to be -6.23 .

HCNO (aq.). Berthelot²⁷ measured the heat of reaction of aqueous potassium cyanate with aqueous hydrochloric acid, and Lemoult¹ that of aqueous barium cyanate with aqueous nitric acid and with aqueous sulfuric acid.

$(\text{NH}_2)_2\text{CO}$ (c). The heat of combustion of urea was measured by Berthelot and Petit,¹ Emery and Benedict,¹ Krummacker,¹ and Stohmann and Langbein.²

$(\text{NH}_2)_2\text{CO}$ (aq.). The heat of solution of urea was measured by Thomsen,¹⁵ Berthelot and Petit,⁵ Matignon,¹ and Walker and Wood.¹ Data on the heat of dilution of aqueous urea were reported by Naudé,² Perman and Lovett,¹ and Fricke and Havestadt.¹

$(\text{NH}_2)_2\text{CO} \cdot \text{HNO}_3$ (aq.). Thomsen¹⁵ measured the heat of mixing aqueous urea with aqueous nitric acid.

$(\text{NH}_2)_2\text{CO} \cdot \text{HNO}_3$ (c). Matignon measured the heat of solution of urea nitrate.

HCONH_2 (liq.). The data of Stohmann and Schmidt⁴ (see Karasch¹) on the heat of combustion of liquid formamide yield $Q_f = 62.1$.

HCONH_2 (aq.). Calvet^{1, 2} found $Q = 6.73$ for the reaction, HCONH_2 (200) + NaOH (200) = HCOONa (200) + NH_3 (200); whence, for aqueous formamide, $Q_f = 57.8$. Berthelot found $Q = 1.0$ for the reaction of HCONH_2 (aq.) with H_2O (liq.); whence, for aqueous formamide, $Q_f = 61.9$.

CH_3CONH_2 (aq.). Calvet^{1, 2} reported $Q = 6.55$ for the reaction, CH_3CONH_2 (200) + NaOH (200) = CH_3COONa (200) + NH_3 (200); whence, for CH_3CONH_2 (200), $Q_f = 75.93$.

CH_3CONH_2 (c). The data of Stohmann and Schmidt⁴ and Berthelot and Fogh¹ on the heat of combustion of crystalline acetamide yield $Q_f = 77.2$ and 71.7 , respectively. Speyers¹ measured the heat of solution

of crystalline acetamide in water to be -1.98 at 23° , while Berthelot and Fogh¹ and Calvet^{1, 2} found -1.85 and -2.05_{200}^{17} , respectively. The last value yields, for CH_3CONH_2 (c), $Q_f = 77.98$.

CH_3CONH_2 (liq.). Bridgman⁷ reported a value for the heat of fusion.

CH_3NO_2 (liq.). Thomsen¹⁵ measured the heat of combustion of gaseous nitromethane and Berthelot and Matignon⁷ and Swietoslawski⁶ that of liquid nitromethane. Their data yield, respectively, for CH_3NO_2 (liq.), $Q_f = 25.3$, 27.6 , and 27.2 .

CH_3NO_2 (g). For the heat of vaporization of nitromethane, the data are: Berthelot and Matignon,⁷ -6.98 at 22° ; Mathews,² -8.25 at 99° . The vapor pressure data of Williams¹ are in accord with the latter value.

CH_3NO_2 (aq.). Berthelot and Matignon⁷ measured the heat of solution of liquid nitromethane in water.

CH_2NO_2^- (aq.). Berthelot and Matignon⁷ measured the heat of solution of liquid nitromethane in aqueous KOH to be 7.0 .

HCOONH_4 (aq.). Berthelot¹¹ measured the heat of neutralization of aqueous formic acid with aqueous ammonia to be 11.9_{200}^{10} .

HCOONH_4 (c). Berthelot¹¹ measured the heat of solution of ammonium formate.

NH_4HCO_3 (aq.). Berthelot⁴ and Berthelot and Andre¹ reported values for the heat of neutralization of NH_4OH (aq.) with H_2CO_3 (aq.). Data on the heat of dilution of ammonium bicarbonate were reported by Thomsen¹⁵.

NH_4HCO_3 (c). Berthelot and Andre¹ measured the heat of solution. Bonnier¹ measured the dissociation pressure.

$(\text{NH}_2)_2\text{C}(:\text{NH})\cdot\text{HNO}_3$ (c). Matignon¹ measured the heat of combustion of guanidine nitrate.

$(\text{NH}_2)_2\text{C}(:\text{NH})\cdot\text{HNO}_3$ (aq.). Matignon¹ measured the heat of solution of guanidine nitrate.

$(\text{NH}_2)_2\text{CNH}$ (aq.). Matignon¹ measured the heat of neutralization of aqueous guanidine nitrate to be 14.1 , whence, for aqueous guanidine, $Q_f = 32.3$.

$(\text{NH}_2)_2\text{CNH}$ (c). Matignon¹ measured the heat of solution of a sample of crystalline guanidine that contained nearly one-half mole of water to be 1.23 .

$(\text{NH}_4)_2\text{CO}_3$ (aq.). Thomsen¹⁵ and Berthelot⁴ measured the heat of neutralization of aqueous ammonia with aqueous carbon dioxide.

$\text{NH}_2\text{COONH}_4$ (aq.). Aqueous ammonium carbamate is taken equivalent to $(\text{NH}_4)_2\text{CO}_3$ (aq.) $-\text{H}_2\text{O}$ (liq.).

$\text{NH}_2\text{COONH}_4$ (c). The data on the heat of solution are: Matignon,⁹ -3.80 at 15° ; Raabe,¹ -3.45 . Raabe¹ and Clark and Hetherington¹ reported for the heat of the reaction, 2NH_3 (g) $+\text{CO}_2$ (g) $=\text{NH}_2\text{COONH}_4$ (c), $Q = 39.3$ and 38.06 , respectively, whence, for solid ammonium carbamate, $Q_f = 160.7$ and 159.45 . Equilibrium data on this last reaction were reported by Briggs and Migrdichian,¹ Briner,¹ Matignon and Frejacques,¹ and Isambert.⁸ See also Lecker¹ and Hori.¹

HOCH₂CN (liq.). Berthelot and Andre⁴ measured the heat of combustion of liquid glycollic nitrile.

CH₃NCO (liq.). Lemoult⁹ measured the heat of combustion of liquid methyl isocyanate.

NH₂OCCOOH (c). Matignon¹ and Stohmann and Haussmann^{1, 2} found 128.6 and 132.6, respectively, for the heat of combustion of solid oxamic acid.

NH₂OCCOOH (aq.). Matignon¹ measured the heat of solution of solid oxamic acid.

NH₂OCCOO⁻ (aq.). Matignon¹ measured the heat of reaction of aqueous oxamic acid with aqueous potassium hydroxide.

(CONH₂)₂ (c). Stohmann and Haussmann^{1, 2} measured the heat of combustion of solid oxamide.

NH₂OCNHCHO (liq.). Matignon¹ measured the heat of combustion of liquid formylurea.

CH₃CHNOH (c). Landrieu¹ (see Kharasch¹) measured the heat of combustion of solid acetaldoxime.

CH₂OHCOONH₄ (aq.). de Forcrand³ measured the heat of neutralization of aqueous glycollic acid with aqueous ammonia.

CH₂OHCOONH₄ (c). de Forcrand³ measured the heat of solution of ammonium glycollate.

NH₂CH₂COOH (c). The heat of combustion of aminoacetic acid, glycine, was measured by Stohmann and Langbein² and Wrede² to be 234.5 and 233.4, respectively.

NH₂CH₂COOH (aq.). Louguinine¹ measured the heat of solution of solid aminoacetic acid, glycine.

NH₂CH₂COO⁻ (aq.). Louguinine¹ found $Q = 2.97$ for the reaction of aqueous aminoacetic acid with aqueous OH⁻ to form aqueous glycinate, or aminoacetate, ion. Branch and Miyamoto¹ from conductivity measurements, calculated the heat of ionization of aqueous aminoacetic acid into aqueous H⁺ and aqueous glycinate ion to be -10.70 .

NH₂CH₂COOH · H⁺ (aq.). Branch and Miyamoto¹ calculated, from conductivity, data $Q = -14.60$ for the reaction, H₂O (liq.) + NH₂CH₂COOH (aq.) = OH⁻ (aq.) + NH₂CH₂COOH · H⁺ (aq.).

C₂H₅NO₂ (g). Thomsen¹⁵ measured the heat of combustion of gaseous nitroethane, and Berthelot and Matignon⁶ that of the liquid. Their data yield, for gaseous nitroethane, $Q_f = 22.2$ and 27.7 , respectively.

C₂H₅NO₂ (liq.). Berthelot and Matignon⁶ measured the heat of vaporization of nitroethane.

C₂H₅NO₂ (aq.). We have estimated the heat of solution of liquid nitroethane.

C₂H₄NO₂⁻ (aq.). Berthelot and Matignon⁶ measured the heat of reaction of aqueous nitroethane with aqueous OH⁻ to be 10.1.

C₂H₅ONO (g). Thomsen¹⁵ measured the heat of combustion of gaseous ethyl nitrite to be 333.9; whence $Q_f = 25.9$.

$\text{C}_2\text{H}_5\text{ONO}_2$ (g). Thomsen¹⁵ measured the heat of combustion of gaseous ethyl nitrate to be 326.4; whence $Q_f = 33.4$.

$\text{C}_2\text{H}_5\text{ONO}_2$ (liq.). We have estimated the heat of vaporization of ethyl nitrate.

$\text{NH}_4\text{HC}_2\text{O}_4$ (aq.). Berthelot¹³¹ measured the heat of reaction of NH_3 (aq.) with $\text{H}_2\text{C}_2\text{O}_4$ (aq.) to form aqueous ammonium acid oxalate. See also Andrews.¹¹

$(\text{NH}_4)_2\text{C}_2\text{O}_4$ (aq.). Berthelot¹³¹ measured the heat of neutralization of aqueous ammonia with aqueous oxalic acid.

$(\text{NH}_4)_2\text{C}_2\text{O}_4$ (c). Berthelot¹³¹ measured the heat of solution of ammonium oxalate.

$(\text{NH}_4)_2\text{C}_2\text{O}_4 \cdot \text{H}_2\text{O}$ (c). Berthelot¹³¹ measured the heat of solution of ammonium oxalate monohydrate.

$\text{C}_2\text{H}_5\text{NHNNO}_2$ (liq.). Swarts^{4, 5} (see Kharasch¹) measured the heat of combustion of ethylnitroamine.

$(\text{CH}_3)_2\text{NNO}_2$ (liq.). Swietoslawski⁶ measured the heat of combustion of liquid dimethylnitrosoamine.

$\text{CH}_3\text{NH}_2 \cdot \text{H}_2\text{CO}_3$ (aq.). Muller⁶ measured the heat of reaction of 1 mole of aqueous methylamine with 1 mole of aqueous carbon dioxide.

$\text{CH}_3\text{COONH}_4$ (aq.). The heat of neutralization of aqueous acetic acid with aqueous ammonia was measured by Thomsen,¹⁵ Berthelot,^{9, 31} and Andrews.¹¹ Data on the heat of dilution of aqueous ammonium acetate were reported by Thomsen¹⁵ and Dunnington and Hoggard.¹

$\text{CH}_3\text{COONH}_4$ (c). Berthelot¹³¹ measured the heat of solution of ammonium acetate.

$(\text{CH}_2\text{NH}_2)_2 \cdot \text{H}_2\text{O}$ (c). Berthelot¹¹⁸ measured the heat of combustion of solid ethylene diamine monohydrate.

$(\text{CH}_2\text{NH}_2)_2$ (aq.). Berthelot¹¹⁸ measured the heat of solution of ethylene diamine monohydrate in water to be 5.08_{1000}^{25} .

$(\text{CH}_2\text{NH}_2)_2 \cdot 2 \text{HCl}$ (aq.). Berthelot¹¹⁸ measured the heat of reaction of aqueous ethylene diamine with 2HCl (aq.) to be 23.2; Colson and Darzen¹ found 23.5.

$(\text{CH}_2\text{NH}_2)_2 \cdot 2 \text{HCl}$ (c). Berthelot¹¹⁸ and Colson and Darzen¹ measured the heat of solution of ethylene diamine dihydrochloride to be -6.65^{25} and -7.6 , respectively.

$(\text{CH}_2\text{NH}_2)_2 \cdot 2 \text{HNO}_3$ (aq.). Berthelot¹¹⁸ measured the heat of reaction of aqueous ethylene diamine with 2HNO_3 (aq.) to be 23.2.

$(\text{CH}_2\text{NH}_2 \cdot \text{H})_2^{++}$ (aq.). The value for aqueous ethylene diaminium ion is obtained from aqueous ethylene diamine dihydrochloride.

CH_2FONH_2 (c). Swarts⁵ (see Kharasch¹) measured the heat of combustion of monofluoroacetamide.

CNCl (liq.). Berthelot²⁷ found $Q = 61.7$ for the reaction, CNCl (liq.) $+ 2 \text{H}_2\text{O}$ (liq.) $= (\text{NH}_4\text{Cl} + \text{CO}_2)$ (aq.).

CNCl (g). Berthelot²⁷ measured the heat of vaporization. Vapor pressure data were reported by Regnault.⁶

$\text{CH}_2\text{ClCOONH}_4$ (aq.). Rivals¹ measured the heat of neutralization of aqueous monochloroacetic acid with aqueous ammonia.

$\text{CCl}_3\text{COONH}_4$ (aq.). Rivals¹ measured the heat of neutralization of aqueous trichloroacetic acid with aqueous ammonia.

$\text{CH}_2\text{ClCONH}_2$ (c). Rivals¹ measured the heat of combustion of monochloroacetamide.

$\text{CH}_2\text{ClCONH}_2$ (aq.). Calvet² measured the heat of reaction of aqueous monochloroacetamide with aqueous KOH to be 9.01.

$\text{CHCl}_2\text{CONH}_2$ (aq.). Calvet² measured the heat of reaction of aqueous dichloroacetamide with aqueous NaOH to be 10.12.

$\text{CCl}_3\text{CONH}_2$ (c). Rivals^{3, 4} measured the heat of combustion of trichloroacetamide.

$\text{CCl}_3\text{CONH}_2$ (aq.). Calvet² measured the heat of reaction of aqueous trichloroacetamide with aqueous NaOH to be 19.71.

$\text{CHF}_2\text{CH}_2\text{NH}_2$ (liq.). Swarts^{4, 5} measured the heat of combustion of liquid difluoroethylamine.

$\text{CHF}_2\text{CH}_2\text{NHNO}_2$ (c). Swarts^{4, 5} measured the heat of combustion of solid difluoroethylnitroamine.

CNI (aq.). Berthelot²⁷ found $Q=6.4$ for the reaction, KCN (aq.) + I_2 (c) = $(\text{CNI} + \text{KI})$ (aq.).

CNI (c). Berthelot²⁷ measured the heat of solution.

CNS^- (∞). This value is obtained from those for NaCNS (∞) and KCNS (∞).

NH_4CNS (aq.). This value is obtained from those for the aqueous ions.

NH_4CNS (c). Berthelot⁹ measured the heat of solution of ammonium thiocyanate. Matignon¹ measured the heat of combustion.

$(\text{NH}_2)_2\text{CS}$ (c). Matignon¹ measured the heat of combustion of thiourea.

$(\text{NH}_2)_2\text{CS}$ (aq.). Matignon¹ measured the heat of solution of solid thiourea.

$(\text{NH}_2)_2\text{CS} \cdot \text{HNO}_3$ (aq.). Matignon¹ measured the heat of mixing aqueous thiourea with aqueous nitric acid to be 0.07.

$(\text{NH}_2)_2\text{CS} \cdot \text{HNO}_3$ (c). Matignon¹ measured the heat of solution of thiourea nitrate.

$(\text{C}_2\text{H}_5)_3\text{PO}_4$ (liq.). Cavalier¹ measured the heat of reaction of POCl_3 (liq.) with 3 $\text{NaC}_2\text{H}_5\text{O}$ (benzene) to be 109.8.

CH_3CNS (g). The data of Thomsen¹⁵ on the heat of combustion of gaseous methyl thiocyanate yield, for CH_3CNS (g), $Q_f = -36.2$.

CH_3CNS (liq.). The data of Berthelot¹²⁰ on the heat of combustion of liquid methyl thiocyanate yield, for CH_3CNS (liq.), $Q_f = -18.5$.

CH_3NCS (g). The data of Thomsen¹⁵ on the heat of combustion of gaseous methyl isothiocyanate yield, for CH_3NCS (g), $Q_f = -29.3$.

CH_3NCS (c). The data of Berthelot¹²⁰ on the heat of combustion of solid methyl isothiocyanate yield, for CH_3NCS (c), $Q_f = -8.3$.

SILICON

Si (c). Standard state.

Si (amorphous). The data of von Wartenberg,² who measured the heats of combustion of both the crystalline and amorphous forms of silicon, yield for the latter $Q_f = -1.0$.

Si (g). von Wartenberg² considered the vapor to be polyatomic and gave -44 as the heat of sublimation. Recently Ruff and Kenschak¹ measured what they believed to be the vapor pressure of silicon, and deduced the heat of sublimation to be -85 at 18° . The heat of sublimation of silicon can also be computed by utilizing the lattice energy of SiO_2 , which is 3247 according to Hylleraas,² but the value obtained is a small difference of very large numbers and the uncertainty may be as much as 200 .

The energy states of gaseous monatomic silicon are taken from the following works: first spectra, Fowler^{2, 4}; second, Fowler⁵ and Bowen⁴; third, Fowler⁵ and Sawyer and Paschen¹; fourth, Fowler⁵; fifth, Edlen and Ericson.¹

SiO_2 (solid). The heat of combustion of silicon to form silicon dioxide was measured by Potter,¹ von Wartenberg,² and Roth,⁴ who found, respectively, $Q = 215, 195$, and 204.0 . Mixer⁵ measured the heats of the reactions, $\text{Si (c)} + 2 \text{Na}_2\text{O}_2 \text{ (c)} = \text{Na}_2\text{SiO}_3 \text{ (c)} + \text{Na}_2\text{O (c)}$ and $\text{SiO}_2 \text{ (gls.)} + \text{Na}_2\text{O (c)} = \text{Na}_2\text{SiO}_3 \text{ (solid, fused)}$, to be 234.6 and 73.27 , respectively; whence, for $\text{Si (c)} + 2 \text{Na}_2\text{O}_2 \text{ (c)} = \text{SiO}_2 \text{ (gls.)} + 2 \text{Na}_2\text{O (c)}$, $Q = 161.0$, and for $\text{SiO}_2 \text{ (gls.)}$, $Q_f = 200.8$. The various solid forms of SiO_2 are silica glass, α and β quartz, α and β cristobalite, and tridymite. The thermal properties of the various forms are determined from data on their heats of solution in concentrated aqueous HF which have been obtained by Mulert,¹ Ray,¹ Wietzel,¹ and from data on heat capacities which have been obtained by Wietzel,¹ Cohn,¹ Neumann,¹ Perrier and Roux,¹ and White.¹ The values we have selected for the heats of solution in 35% aqueous HF are: $\text{SiO}_2 \text{ (gls.)}$, 36.98 ; $\text{SiO}_2 \text{ (quartz)}$, 33.65 ; $\text{SiO}_2 \text{ (colloid)}$, 38.9 .

SiO_2 (liq.). From melting point curves, Kracek¹ calculated the heat of fusion of cristobalite to be -1.84 at 1530° .

SiO_2 (g). Ruff and Schmidt¹ measured the vapor pressure of silica. Their data, which are not very concordant, yield a value of about -79 for the heat of vaporization at 1900° .

H_2SiF_6 (aq.). The heat of solution of silica glass in aqueous HF varies considerably with the concentration of the acid, as shown by the following data: Ray,¹ 37.24 in 35% HF ; Mulert,¹ 32.14 in 20% HF ; Wietzel,¹ 35.97 in 35% HF , and 38.8 in fuming HF . Mulert¹ measured the heat of solution of silica containing various amounts of water in the same acid used for the solution of silica glass, and found that beyond $\text{SiO}_2 \cdot 50 \text{H}_2\text{O}$, the heat of solution was constant and equal to 33.6 in 20% HF . Mulert¹ also measured the heat of solution of the same hydrated material in exactly 6 moles of dilute acid, obtaining 32.3 .

From these data we have computed $Q=30.7$ for the reaction, SiO_2 (gls.) $+6\text{HF}$ (6) $=\text{H}_2\text{SiF}_6$ (aq.), whence, for H_2SiF_6 (aq.), $Qf=547.8$.

SiF_4 (g). The data of von Wartenberg and Schutte,¹ who measured directly the heat of formation of this substance, give for SiF_4 (g), $Qf=359.7$ Truchot^{1, 2, 3} measured the heat of solution of SiF_4 (g) in 2 moles of aqueous HF to be 34.0; Guntz¹ found 33.50. Selecting the value 33.8, we have computed, for SiF_4 (g), $Qf=363.0$.

Johnson and Jenkins¹ reported a critical potential of 5.03 volt-electrons for the SiF_4 molecule, but the excited state is not known.

SiF_4 (liq.), SiF_4 (c). The vapor pressure data of Patnode and Papish,¹ Ruff and Ascher,¹ and LeBoucher, Fischer, and Biltz¹ yield -4.46 ⁻⁹⁰ for the heat of vaporization and -6.16 ⁻⁹⁵ for the heat of sublimation.

$\text{SiO}_2 \cdot n\text{H}_2\text{O}$ (c). Silicic acids of almost every possible composition have been described, but there seems to be no evidence that these substances are definite compounds. Mulert¹ measured the heats of solution of the hydrates ranging in composition from $\text{SiO}_2 \cdot \text{H}_2\text{O}$ to $\text{SiO}_2 \cdot 86.6 \text{H}_2\text{O}$, and found no break in the curve representing the relation between the heat of solution and the number of moles of water in the so-called hydrates. On the other hand, Thiessen and Koerner¹ obtained some vapor pressure evidence indicating the existence of the hydrates containing $\frac{1}{2}$, 1, $1\frac{1}{2}$, and 2 moles of water. Their data yield 12.7, 10.9, 10.1, and 8.7 for the respective heats of dissociation per mole of water vapor.

SiH_4 (g). Ogier¹ measured the heat of combustion to be 324.3, whence, for SiH_4 (g), $Qf=13.7$. The equilibrium data of von Wartenberg² yield $Qf=8.7$.

SiH_4 (liq.). Wintgen¹ reported -3.03 for the heat of vaporization of the liquid at the boiling point, -112° .

$\text{Si}_n\text{H}_{2n+2}$ (g). Wintgen¹ reported the heats of vaporization for Si_2H_6 , Si_3H_8 , and Si_4H_{10} .

SiCl_4 (liq.). Troost and Hautefeuille^{4, 5} measured the heat of the direct combination of amorphous silicon and gaseous chlorine to form liquid silicon tetrachloride, reporting $Q=157.6$. Berthelot⁵⁰ reviewed their data and deduced $Q=150.1$, by making some calorimetric corrections to their data. For the heat of the reaction, SiCl_4 (liq.) $+2\text{H}_2\text{O}$ (liq.) $=\text{SiO}_2$ (aq., colloid) $+4\text{HCl}$ (aq.), the following values were reported: Troost and Hautefeuille,^{3, 5} 70.0; Roth and Schwartz,¹ 70.1; Berthelot,⁵⁰ 69.7; Thomsen,¹⁵ 69.3. From these data, we have computed, for SiCl_4 (liq.), $Qf=150.1$.

SiCl_4 (g). The calorimetric data on the heat of vaporization of the liquid at 57° are: Ogier,¹ -6.3 ; Stock, Somiesky, and Wintgen,¹ -7.19 ; Wintgen,¹ -7.19 . These values are in accord with the vapor pressure data of Regnault⁶ and Becker and Meyer.¹ Kahlenberg and Koenig¹ deduced -6.2 by an uncertain method.

SiCl_4 (c). Latimer¹ found $F=-1.85$ at -70° .

SiBr₄ (liq.). Berthelot⁵⁰ found the heat of reaction of this substance with water to be 83.0, whence, for SiBr₄ (liq.), $Q_f = 93.6$.

SiI₄ (c). Berthelot⁵⁰ found the heat of reaction of this substance with water to be 85.7, which gives, for SiI₄ (c), $Q_f = 29.8$.

SiH₂Cl₂ (g). Stock and Somieski³ reported $V = -6.1^{12}$.

SiH₃Cl (g). Stock and Somieski³ reported $V = -5.1^{10}$.

SiH₂Br₂ (g). Stock and Somieski² reported $V = -7.4^{66}$.

SiH₃Br (g). Stock and Somieski¹ reported $V = -5.85^2$.

(SiCl₃)₂O (g). Stock, Somieski, and Wintgen¹ reported $V = -9.4^{137}$.

Si₂Cl₆ (g). Guinchant^{4, 5} reported $V = -11.0^{139}$.

Si₃Cl₈ (g). Guinchant^{4, 5} reported $V = -12.1^{213}$.

SiS₂ (c). Sabatier¹ measured the heat of the reaction $\text{SiS}_2 (\text{c}) + 2\text{H}_2\text{O} (\text{liq.}) = \text{SiO}_2 (\text{colloid, aq.}) + 2\text{H}_2\text{S} (\text{g})$, finding $Q^{9,5} = 38.8$ and 54.0, respectively, for white and yellow SiS₂.

Si₃N₄ (c). Hincke and Brantley,¹ from their equilibrium data on the reaction, $\text{Si}_3\text{N}_4 (\text{c}) = 3\text{Si} (\text{c}) + 2\text{N}_2 (\text{g})$, computed $Q^{1600} = -176.3$, which gives $Q_f = 157$. Matignon^{10, 13} measured the equilibrium $3\text{SiO}_2 (\text{c}) + 6\text{C} (\text{amorphous}) + 2\text{N}_2 (\text{g}) = \text{Si}_3\text{N}_4 (\text{c}) + 6\text{CO} (\text{g})$, and computed, with the aid of the Nernst equation, $Q = -203$, whence, for Si₃N₄ (c), $Q_f = 230$.

(NH₄)₂SiF₆ (aq.). Truchot³ found $Q = 31.2^{20}$ for the reaction $\text{SiF}_4 (\text{g}) + 2\text{NH}_4\text{F} (\text{aq.}) = (\text{NH}_4)_2\text{SiF}_6 (\text{aq.})$.

(NH₄)₂SiF₆ (c). Truchot³ measured the heat of solution.

(C₂H₅O)₄Si (liq.) Ogier¹ measured the heat of hydrolysis of this substance to be 21.6.

(CH₃O)₄Si (g). Kahlenberg and Koenig¹ reported $V = -7.08^{121}$.

SiC (c). von Wartenberg and Schutte¹ measured the heat of the reaction of gaseous fluorine with silicon carbide to be 491.3, from which we find $Q_f = 30$. The data of Mixer⁵ yield for the reactions, $\text{SiC} (\text{c}) + 4\text{Na}_2\text{O}_2 (\text{c}) = \text{Na}_2\text{SiO}_3 (\text{gls.}) + \text{Na}_2\text{CO}_3 (\text{c}) + 2\text{Na}_2\text{O} (\text{c})$ and $\text{Si} (\text{c}) + 2\text{Na}_2\text{O}_2 (\text{c}) = \text{Na}_2\text{SiO}_3 (\text{gls.}) + \text{Na}_2\text{O} (\text{c})$, $Q = 365.9$ and 234.6, respectively. The difference gives for $\text{SiC} (\text{c}) + 2\text{Na}_2\text{O}_2 (\text{c}) = \text{Si} (\text{c}) + \text{Na}_2\text{CO}_3 (\text{c}) + \text{Na}_2\text{O} (\text{c})$, $Q = 131.3$, from which, for SiC (c), $Q_f = 0.2$. The vapor pressure data of Ruff and Kenschak¹ yield the approximate value, $Q_f = 25$. The equilibrium data of Baure and Brunner¹ yield the estimated value 36. Ruff and Grieger¹ measured the heats of the reactions studied by Mixer⁵ (see above) and found $Q = 375.1$ and 259.3, respectively. The differences give, for $\text{SiC} (\text{c}) + 2\text{Na}_2\text{O}_2 (\text{c}) = \text{Si} (\text{c}) + \text{Na}_2\text{CO}_3 (\text{c}) + \text{Na}_2\text{O} (\text{c})$, $Q = 115.8$, from which, for SiC (c), $Q_f = 15.7$.

GERMANIUM

Ge (c). Standard state.

Ge (g). We have estimated the heat of sublimation to be -85. The energy states of monatomic gaseous germanium are evaluated from the data of Rao,⁴ Gartlein,¹ Lang,¹ and Rao and Narayan.²

GeO₂ (colloid, aq.). We have estimated $Q_f = 230$.

GeCl₄ (liq.). Roth and Schwartz¹ measured the heat of solution of this substance in water to be 25, whence, for GeCl₄ (liq.), $Q_f = 226.1$.

GeCl₄ (g). The vapor pressure data of Nilson and Petterson¹ yield -9.28° for the heat of vaporization of the liquid.

Ge₂H₆ (g). Dennis, Corey, and Moore¹ reported $V = -6.3^{29}$.

Ge₃H₈ (g). Dennis, Corey, and Moore¹ reported $V = -7.6^{111}$.

TIN

Sn (c). The three solid forms of tin are: I, rhombic, white; II, tetragonal, white; III, cubic, gray. The transition temperatures are respectively 161° and 18° . We have selected Sn (c, II, tetragonal) as the standard state. For the heat of transition of III to II, the data are: Brönsted,⁶ -0.53 ; Cohen,³ -0.73 ; Meyer,¹ -1.13 . For the heat of transition from II to I, Werner² reported -0.002 .

Sn (liq.). The data on the heat of fusion of tin at the melting point, 232° , are: Awbery and Griffiths,¹ -1.73 ; Iitaka,¹ -1.59 ; Umino,³ -1.69 ; Person,² -1.69 ; Rudberg,¹ -1.58 ; Mazzotto,³ -1.61 ; Spring,¹ -1.74 ; Guinchant,⁵ -1.70 ; Pionchon,¹ -1.73 ; Robertson,¹ -1.66 .

Sn (g). Vapor pressure data on liquid tin were obtained by Ruff and Bergdahl,¹ Greenwood,^{2, 3, 5, 6} van Liempt,² von Wartenberg,⁹ and Harteck.¹ The data are discordant. We have taken -75 as the best value for the heat of vaporization of the liquid and have assumed the vapor to be monatomic.

Values for the energy states of monatomic gaseous Sn are taken from the following: Bach,³ Green and Loring,¹ Narayan and Rao,¹ Randall and Wright,¹ Carroll,¹ Rao,¹ Gibbs and White,² Gibbs and Vieweg,¹ Lang,² and Rao, Narayan, and Rao.¹

SnH₄ (liq.). From vapor pressure data, Paneth, Haken, and Rabinowitsch¹ computed $V = -4.55^{150}$.

SnO₂ (c, III). For the heat of combustion of tin to form SnO₂, the data are: Dulong,² 145; Andrews,¹⁴ 136; Mixter,⁷ 137.8; Moose and Parr,¹ 138.8. From data on the entropies of SnO₂, Sn, and O₂, and the free energy of formation of SnO₂, Millar⁵ computed, for SnO₂ (c, III), $Q_f = 137.8$.

SnO₂ (c, I), SnO₂ (c, II). Laschtschenko¹ found the heats of transition of III to II and II to I to be -0.45^{430} and -0.30^{540} , respectively.

SnO (c). For the heat of oxidation of SnO to form SnO₂, the data are: Mixter,⁷ 70.4; Andrews,¹⁴ 69.6; Dulong,² 71. Using Mixter's value of 70.4, we have computed, for SnO, $Q_f = 67.7$. Equilibrium measurements involving SnO were made by Maeda,¹ Fraenkel and Snipischski,¹ Rosenhain,¹ and Eastman and Robinson.¹

SnCl₂ (aq. HCl). Thomsen¹⁵ measured the heat of the reaction, $\text{SnCl}_2 (\text{aq. HCl}) + \text{Zn (c)} = \text{ZnCl}_2 (\text{aq. HCl}) + \text{Sn (c)}$, finding $Q = 33.0, 33.5, 33.0, 33.2, 30.2, 30.5, 28.9, \text{ and } 30.9$. Disregarding the four low values, we have computed, for SnCl₂ (aq. HCl), $Q_f = 81.5$.

SnCl₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 0.35; Biltz and Fischer,² 0.8; Berthelot,⁵⁰ 0.40.

SnCl₂ · 2H₂O (c). The data on the heat of solution are: Thomsen,¹⁵ -5.29₂₀₀; Berthelot,¹³¹ -5.26.

SnCl₂ (g). For the heat of vaporization of stannous chloride, Maier⁶ reported -21.1 at 623°.

SnCl₄ (aq. HCl). Thomsen's¹⁵ data on the reaction, SnCl₂ (aq. HCl) + HCl (aq.) + HClO (aq.) = SnCl₄ (aq. HCl) + H₂O (liq.), yield $Q = 74.97$; whence, for SnCl₄ (aq. HCl), $Q_f = 157.34$. Thomsen¹⁵ also measured the heat of oxidation of SnCl₂ (aq. HCl) with aqueous HIO₃ and with aqueous H₂O₂. His data yield, $Q = 155.50$ and 88.74 , respectively; whence, for SnCl₄ (aq. HCl), $Q_f = 157.66$ and 158.1 . The last value is not given great weight because the reaction involving H₂O₂ may not be clear cut. Berthelot²⁶ measured the heat of the reaction SnCl₂ (aq. HCl) + Cl₂ (g) = SnCl₄ (aq. HCl). His data yield $Q = 76.0$; whence, for SnCl₄ (aq. HCl), $Q_f = 157.5$.

SnCl₄ (liq.). Thomsen¹⁵ found the heat of solution of liquid stannic chloride to be 29.92^{20} ; Berthelot⁵⁰ found 28.5 .

SnCl₄ (c). Latimer¹ measured the heat of fusion to be -2.20^{33} .

SnCl₄ (g). The heat of vaporization of liquid stannic chloride was measured by Kahlenberg and Koenig,¹ Hammick,¹ and Andrews.¹⁰ Vapor pressure data were obtained by Regnault,⁶ Mundel,¹ and Young.² For the heat of vaporization, Andrews¹⁰ found -8.0 and Hammick¹ -8.5 ; Young² calculated -9.0 .

Sn(OH)₂ (c). Thomsen¹⁵ reported $Q = 24.72$ for the reaction, SnCl₂ (aq.) + 2NaOH (aq.) = 2NaCl (aq.) + Sn(OH)₂ (c). This gives, for the freshly precipitated stannous hydroxide, $Q_f = 136.1$.

Sn(OH)₄ (c). Thomsen¹⁵ reported $Q = 51.87$ for the reaction, SnCl₄ (aq.) + 4NaOH (aq.) = 4NaCl (aq.) + Sn(OH)₄ (c). This gives, for the freshly precipitated stannic hydroxide, $Q_f = 268.9$.

SnBr₂ (c). By means of "double decomposition" or "reciprocal pair" experiments Berthelot⁵⁰ found, for SnCl₂ (c) + 2KBr (aq.) = SnBr₂ (c) + 2KCl (aq.), $Q = 2.20$; whence, for SnBr₂ (c), $Q_f = 61.4$.

SnBr₂ (aq.). The data on the heat of solution of SnBr₂ (c) are: Berthelot,⁵⁰ 1.6 ; Biltz and Fischer,² 1.6 .

SnI₂ (c). In a manner similar to that for stannous bromide, Berthelot⁵⁰ found, for SnCl₂ (c) + 2KI (aq.) = SnI₂ (c) + 2KCl (aq.), $Q = 4.0$; whence, for SnI₂ (c), $Q_f = 38.9$.

SnI₂ (aq.). Mosnier¹ found the heat of solution of SnI₂ (c) to be 0.61 .

H₂SnF₆ (aq.). For the reaction, SnCl₄ (aq. HCl) + 6HF (aq.) = (H₂SnF₆ + 4HCl) (aq.), Thomsen¹⁵ found $Q = 17.6$. This gives, for H₂SnF₆ (aq.) $Q_f = 470.4$.

SnF₆⁻ (aq.). Assuming the heat of neutralization of aqueous H₂SnF₆ to be the same as that for H₂SiF₆, 26.6 , we have computed, for SnF₆⁻ (aq.), $Q_f = 469.8$.

SnBr₄ (c). Berthelot⁵⁰ measured the heat of mixing SnCl₄ (liq.) with

4KBr (aq.), and of SnBr_4 (c) with 4KCl (aq.), to be 28.1 and 16.8, respectively. The difference gives, for SnCl_4 (liq.) + 4KBr (aq.) = SnBr_4 (c) + 4KCl (aq.), $Q = 11.3$, from which we have computed, for SnBr_4 (c), $Q_f = 94.8$.

SnBr_4 (aq.). For the heat of solution of solid stannic bromide the data are: Berthelot,⁵⁰ 17.6₈₀₀¹⁰; Pickering,¹² 15.54₁₀₀₀¹⁵. Using the value 15.5, one finds, for SnBr_4 (aq.), $Q_f = 110.3$. Herschkowitsch² measured the heat of solution of tin in a saturated aqueous solution of KBr + Br₂, to form SnBr_4 (aq.), to be 110.2.

SnBr_4 (liq.). The data on the heat of fusion of solid stannic bromide are: Tolloczko,¹ -2.74; Garelli,¹ -2.84; Raoult,¹ -3.14; Berthelot,⁵⁰ -3.10; Pickering,¹² -2.97.

$\text{SnBr}_4 \cdot 8\text{H}_2\text{O}$ (c). Pickering¹² measured the heat of solution.

$\text{SnBr}_4 \cdot 8\text{H}_2\text{O}$ (liq.). Pickering¹² measured the heat of fusion of the solid octahydrate.

SnS (c). There are no calorimetric data on this substance. The equilibrium data of Jellinek and Zakowsky¹ yield, for SnS (c) + H₂ (g) = Sn (liq.) + H₂S (g), $Q = -20.0$; whence, for SnS (c), $Q_f = 22.7$.

$\text{Sn}(\text{SO}_4)_2$ (c). Beck¹ found $Q = 91.1$ for the heat of reaction between this substance and 8KOH (aq.). Assuming the reaction, $\text{Sn}(\text{SO}_4)_2$ (c) + 4KOH (aq.) = $2\text{K}_2\text{SO}_4$ (aq.) + $\text{Sn}(\text{OH})_4$ (c), we have computed, for $\text{Sn}(\text{SO}_4)_2$ (c), $Q_f = 391.1$.

$\text{SnCl}_4 \cdot 1\frac{1}{2}\text{PH}_3$ (c). Holtje¹ reported $Q = 17.6$ for the heat of the reaction, SnCl_4 (liq.) + $1\frac{1}{2}\text{PH}_3$ (g) = $\text{SnCl}_4 \cdot 1\frac{1}{2}\text{PH}_3$ (c).

Sn_nBi_m (c). From data on the heats of solution in mercury, Magnus and Mannheimer¹ determined the heats of formation of the solid alloys, SnBi, SnBi_2 , Sn_2Bi , Sn_5Bi , and SnBi_5 .

$\text{SnX}_2 \cdot n\text{NH}_3$ (c). Biltz and Fischer² measured the dissociation pressures at various temperatures for some stannous halide amines, and also determined the heats of solution of some of them in aqueous HCl. Their data are as follows: $\text{SnCl}_2 \cdot 2\frac{1}{2}\text{NH}_3$ (c), $S = 14.0$; $\text{SnCl}_2 \cdot 4\text{NH}_3$ (c), $D = -9.3$; $\text{SnCl}_2 \cdot 9\text{NH}_3$ (c), $D = -7.6$; $\text{SnBr}_2 \cdot \text{NH}_3$ (c), $S = 7.3$; $\text{SnBr}_2 \cdot 3\text{NH}_3$ (c), $D = -12.5$, $S = 14.8$; $\text{SnBr}_2 \cdot 5\text{NH}_3$ (c), $D = -9.8$; $\text{SnBr}_2 \cdot 9\text{NH}_3$ (c), $D = -7.55$; $\text{SnI}_2 \cdot \text{NH}_3$ (c), $D = -16.0$; $\text{SnI}_2 \cdot 2\text{NH}_3$ (c), $D = -13.3$, $S = 6.5$; $\text{SnI}_2 \cdot 3\text{NH}_3$ (c), $D = -11.9$, $S = 14.8$; $\text{SnI}_2 \cdot 5\text{NH}_3$ (c), $D = -10.2$; $\text{SnI}_2 \cdot 9\text{NH}_3$ (c), $D = -7.9$.

LEAD

Pb (c, non-radioactive). Standard state.

Pb (solid, "stick" form). From data on the electromotive force of cells involving lead in both the crystalline and the "stick" form, Gerke¹ found for the transition from the former to the latter $Q = -0.07$.

Pb (liq.). The data on the heat of fusion of lead are: Umino,³ -1.14; Iitaka,¹ -1.14; Robertson,² -1.34; Magnus and Oppenheimer,¹ -1.224; Awbery and Griffiths,¹ -1.295; Person,¹⁰ -1.13; Mazzotto,³ -....; Glaser,² -1.01; Spring,¹ -1.10; Klinkhardt,¹ -1.21.

Pb (g). von Wartenberg⁹ showed that lead vapor is monatomic above 1870°. The vapor pressure data of Harteck,¹ von Wartenberg,^{7, 9} Greenwood,^{2, 3, 5, 6} Ruff and Bergdahl,¹ Rodebush and Dixon,^{1, 2} Egerton,^{3, 4} and Rodebush¹ yield -45 for the heat of vaporization. See also Hildebrand,² Johnson,⁵ and van Leimpt.² From direct but rough measurements, Tate¹ found $V = -37$.

The energy states of gaseous monatomic lead are evaluated from the following: Bacher and Goudsmit,¹ Back,² Gieseler and Grotrian,^{1, 2} McLennan, Young, and McLay,¹ Sponer,² Sur,^{2, 3} Thorsen,^{1, 2} Geiseler,¹ Rao and Narayan,⁴ Smith,⁹ Rao, Narayan, and Rao,¹ and Carroll.¹

PbCl₂ (c). The electromotive force data of Gerke¹ on the cells in which the reactions are: $\text{Pb (c)} + 2\text{AgCl (c)} = \text{PbCl}_2 \text{ (c)} + 2\text{Ag (c)}$ and $\text{Pb (c)} + 2\text{HgCl (c)} = \text{PbCl}_2 \text{ (c)} + 2\text{Hg (liq.)}$, when combined with his own data on the formation of AgCl (c) and HgCl (c), yield, for PbCl₂ (c), $Q_f = 85.71$ and 85.95, respectively. The data of Krahmer,¹ Brönsted,¹ Gunther,¹ Wolff,² and Getman² are in accord with the lower of these values.

PbCl₂ (aq.). The data on the heat of solution of lead chloride in water are: Thomsen,¹⁵ -3.44; Berthelot,⁹ -4.0; Bronsted,⁴ -3.28.

PbCl₂ (liq.). The data on the heat of fusion of lead chloride are: Ehrhardt,¹ -5.8; Weber,¹ -5.61; Rudberg,¹ -5.81; Goodwin and Kalmus,¹ -5.15.

PbCl₂ (g). The vapor pressure data of von Wartenberg and Bosse,¹ Jellinek and Rudat,² Jellinek and Golubowski,¹ Eastman and Duschak,¹ and Maier⁶ yield -28.5 for the heat of vaporization of the liquid at 860°.

PbO (c, red). For the heat of the reaction, $\text{PbO (c, red)} + \text{H}_2 \text{ (g)} = \text{Pb (c)} + \text{H}_2\text{O (liq.)}$, the data of Smith and Wood¹ give 15.91, and those of Fried¹ give 16.6. These values yield, for PbO (c), $Q_f = 52.46$ and 51.8 respectively. From electromotive force measurements Treadwell¹ computed the heat of formation to be 50.4 at high temperatures. Combination of Thomsen's¹⁵ data on the two reactions, $\text{PbO (c)} + 2\text{HNO}_3(200) = \text{Pb(NO}_3)_2(400) + \text{H}_2\text{O (liq.)}$ and $\text{Pb(NO}_3)_2(400) + 2\text{KCl}(200) = 2\text{KNO}_3(400) + \text{PbCl}_2 \text{ (c)}$, yield for the reaction, $\text{PbO (c)} + 2\text{HNO}_3(200) + 2\text{KCl}(200) = 2\text{KNO}_3(400) + \text{H}_2\text{O (liq.)} + \text{PbCl}_2 \text{ (c)}$, $Q = 22.22$. From this we have computed, for PbO (c), $Q_f = 52.91$. Marshall and Bruz¹ measured the heat of solution of PbO in 10 per cent aqueous nitric acid to be 19.8.

Pb(NO₃)₂ (aq.). Thomsen¹⁵ measured the heat of the reaction, $\text{PbO (c)} + 2 \text{HNO}_3(200) = \text{Pb(NO}_3)_2(400) + \text{H}_2\text{O (liq.)}$, and his data yield $Q = 17.76$, whence, for Pb(NO₃)₂(400), $Q_f = 100.05$. It is probable that Thomsen used the yellow form of PbO, in which case the value for aqueous lead nitrate would be a little less than that given above. For the reaction, $\text{Pb(NO}_3)_2(400) + 2 \text{KCl}(200) = \text{PbCl}_2 \text{ (c)} + 2 \text{KNO}_3(400)$, Thomsen¹⁵ reported $Q = 4.46$, from which we have computed, for Pb(NO₃)₂(400), $Q_f = 100.50$. For the similar reaction with aqueous KI, Thomsen¹⁵

reported $Q = 13.79$. This yields, for $\text{Pb}(\text{NO}_3)_2(400)$, $Q_f = 99.80$. Thomsen¹⁵ measured the heat of dilution of aqueous lead nitrate.

$\text{Pb}(\text{NO}_3)_2(c)$. The data on the heat of solution of lead nitrate are: Thomsen,¹⁵ -7.61_{400} ; Favre and Silbermann,³ -7.93 ; Tammann and Krings,¹ -8.49 . See also Berthelot.¹⁰

$\text{PbSO}_4(c, \text{II})$. Thomsen¹⁵ measured the heats of the reactions, $\text{Pb}(\text{NO}_3)_2(400) + \text{H}_2\text{SO}_4(400) = \text{PbSO}_4(c) + 2\text{HNO}_3(400)$, $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2(400) + \text{H}_2\text{SO}_4(400) = \text{PbSO}_4(c) + 2\text{HC}_2\text{H}_3\text{O}_2(400)$, and $\text{Pb}(\text{NO}_3)_2(400) + \text{Na}_2\text{SO}_4(400) = \text{PbSO}_4(c) + 2\text{NaNO}_3(400)$. His data yield $Q = 5.40$, 7.58 , and 1.70 , respectively; whence, for $\text{PbSO}_4(c)$, we have computed $Q_f = 218.30$, 218.80 , and 218.36 . From electromotive force measurements, Klein¹ computed $Q = -2.48$ for the reaction, $\text{PbCl}_2(c) + \text{K}_2\text{SO}_4(100) = \text{PbSO}_4(c) + 2\text{KCl}(50)$, whence, for $\text{PbSO}_4(c)$, $Q_f = 219.99$. Combination of the electromotive force data of Henderson and Stegeman¹ with those of Gerke¹ yield, for $\text{Pb}(c) + \text{Hg}_2\text{SO}_4(c) = \text{PbSO}_4(c) + \text{Hg}(\text{liq.})$, $Q = 42.17$; whence, for $\text{PbSO}_4(c)$, $Q_f = 217.8$. See also Ishikawa.⁴

$\text{PbSO}_4(c, \text{I})$. Hare¹ measured the heat of transition.

$\text{PbO}_2(c)$. Tscheltzow¹ measured the heats of the reactions, $\text{PbO}_2(c) + \text{SO}_2(g) = \text{PbSO}_4(c)$ and $\text{PbO}_2(c) + (2\text{HgNO}_3 + 4\text{HNO}_3)(\text{aq.}) = \text{Pb}(\text{NO}_3)_2 + \text{Hg}(\text{NO}_3)_2(\text{aq.}) + 2\text{H}_2\text{O}(\text{liq.})$, and his data yield $Q = 82.62$ and 31.85 , respectively; whence, for $\text{PbO}_2(c)$, $Q_f = 64.9$ and 63.2 . Vosburgh and Craig¹ measured the electromotive force at various temperatures of the cell in which the reaction is $\text{PbO}_2(c) + 2\text{Hg}(\text{liq.}) + 2\text{H}_2\text{SO}_4(50) = \text{Hg}_2\text{SO}_4(c) + \text{PbSO}_4(c) + 2\text{H}_2\text{O}(\text{liq.})$, and computed $Q = 44.73$ at 25° . This gives, for $\text{PbO}_2(c)$, $Q_f = 64.18$. Millar⁵ computed the entropy of $\text{PbO}_2(c)$ from his data on heat capacities at low temperatures, and utilizing the equilibrium data of Glasstone and Westcott¹ on the reactions, $\text{PbO}_2(c) + \text{H}_2(g) = \text{PbO}(c) + \text{H}_2\text{O}(\text{liq.})$ and $\text{PbCl}_2(c) + \text{Cl}_2(g) + 2\text{H}_2\text{O}(\text{liq.}) = \text{PbO}_2(c) + 4\text{HCl}(g)$, computed, for $\text{PbO}_2(c)$, $Q_f = 65.96$. Mixer⁸ measured the heats of the reactions, $\text{Pb}(c) + 2\text{Na}_2\text{O}_2(c) = \text{Na}_2\text{PbO}_3(c) + \text{Na}_2\text{O}(c)$ and $\text{PbO}_2(c) + \text{Na}_2\text{O}(c) = \text{Na}_2\text{PbO}_3(c)$, finding $Q = 63.6$ and 38.44 , respectively. The difference gives, for $\text{Pb}(c) + 2\text{Na}_2\text{O}_2(c) = \text{PbO}_2(c) + 2\text{Na}_2\text{O}(c)$, $Q = 25.16$; whence, for $\text{PbO}_2(c)$, $Q_f = 64.7$. There is an old value for the heat of formation of lead peroxide obtained by Hess.⁷

$\text{Pb}_3\text{O}_4(c)$. The equilibrium, $2\text{Pb}_3\text{O}_4(c) = 6\text{PbO}(c) + \text{O}_2(g)$, was studied by LeChatelier² and by Reinders and Hamburger.¹ From the data of the former, Biltz⁸ deduced $Q = -32.2$, while the latter gave $Q = -33.5$. These values yield, for $\text{Pb}_3\text{O}_4(c)$, $Q_f = 173.5$ and 174.1 , respectively. For the heat of the reaction, $3\text{PbO}_2(c) = \text{Pb}_3\text{O}_4(c) + \text{O}_2(g)$, Debray² gave -23.8 , which yields, for $\text{Pb}_3\text{O}_4(c)$, $Q_f = 171.2$. See also Henglein.¹ From his own data on the heat capacity down to low temperatures, and from the electromotive force data of Glasstone,¹ Millar⁵ computed, for $\text{Pb}_3\text{O}_4(c)$, $Q_f = 172.4$.

$\text{Pb}_2\text{O}(c)$. For the heats of solution of $\text{Pb}_2\text{O}(c)$ and $\text{PbO}(c)$ in aqueous acetic acid, Herschkowitsch¹ found 16.71 and 15.50 , while

Aufenast and Terry¹ found 15.26 and 15.6, respectively. These data yield, for Pb_2O (c), $Q_f = 51.3$ and 52.8 , respectively.

$\text{Pb}(\text{OH})_2$ (c). The heat of neutralization of $\text{Pb}(\text{OH})_2$ (c) with aqueous nitric acid was measured by Berthelot,⁵ Sveda,¹ Herschkowitsch,¹ Tanatar,⁶ and Aufenast and Terry.¹ Their data yield, for $\text{Pb}(\text{OH})_2$ (c), $Q_f = 122.7$.

PbF_2 (c). Guntz¹ found 2.2 for the heat of reaction of aqueous lead nitrate with aqueous hydrofluoric acid. This gives for PbF_2 (c), $Q_f = 159.5$. From equilibrium data, Jellinek and Rudat¹ calculated $Q_f = 156$.

PbF_2 (g). The vapor pressure data of von Wartenberg and Bosse¹ yield -39.4 for the heat of sublimation at 1200° .

$\text{PbCl}_2 \cdot n\text{PbO}$ (c). Andre¹ measured the heats of solution in aqueous HCl of $\text{PbCl}_2 \cdot \text{PbO}$ (c), $\text{PbCl}_2 \cdot 2\text{PbO}$ (c), and $\text{PbCl}_2 \cdot 3\text{PbO}$ (c). The last named substance may probably be just a mixture, not a true compound.

PbBr_2 (c). Thomsen¹⁵ found $Q = 8.02$ for the reaction, $\text{Pb}(\text{NO}_3)_2(200) + 2\text{KBr}(100) = 2\text{KNO}_3(200) + \text{PbBr}_2$ (c), whence, for PbBr_2 (c), $Q_f = 66.58$. Krahmer¹ gave $Q = -17.96$ for the reaction, Pb (c) $+ 2\text{AgBr}$ (c) $= 2\text{Ag}$ (c) $+ \text{PbBr}_2$ (c); whence, for PbBr_2 (c), $Q_f = 64.58$. Klein¹ reported $Q = 3.56$ for the reaction, PbCl_2 (c) $+ 2\text{KBr}$ (aq.) $= \text{PbBr}_2$ (c) $+ 2\text{KCl}$ (aq.); whence, for PbBr_2 (c), $Q_f = 67.6$. Equilibrium data involving lead bromide were reported by Jellinek and Rudat¹ and Lorenz and Schultz.¹

PbBr_2 (aq.). Thomsen¹⁵ measured the heat of solution of lead bromide.

PbBr_2 (liq.). The data on the heat of fusion are: Weber,¹ -5.01 ; Goodwin and Kalmus,¹ -4.52 . See also Erhardt¹ and Czepinsky.¹

PbBr_2 (g). The vapor pressure data of von Wartenberg and Bosse¹ yield -28 for the heat of vaporization at 916° .

$\text{PbBr}_2 \cdot n\text{PbO}$ (c). Andre¹ measured the heats of solution in aqueous HBr of $\text{PbBr}_2 \cdot \text{PbO}$ (c), $\text{PbBr}_2 \cdot 2\text{PbO}$ (c), and $\text{PbBr}_2 \cdot 3\text{PbO}$ (c).

PbI_2 (c). The data of Gerke¹ on the cell reaction, Pb (c) $+ \text{I}_2$ (c) $= \text{PbI}_2$ (c), yield, for PbI_2 (c), $Q_f = 41.77$. See also Braune and Koref,¹ who reported $Q_f = 41.6$.

PbI_2 (liq.). For the heat of fusion of lead iodide, Ehrhardt¹ found -5.28 at 375° and Czepinski² -5.28 .

PbI_2 (g). The vapor pressure data of Jellinek and Rudat¹ yield -27.7 for the heat of vaporization at 800° .

$\text{PbI}_2 \cdot \text{HI} \cdot 5\text{H}_2\text{O}$ (c). Berthelot⁶⁹ measured the heat of solution of this substance.

PbS (c). Berthelot¹⁴ found the heats of reaction of aqueous hydrogen sulfide to be 13.34 and 11.34 with aqueous lead nitrate and aqueous lead acetate, respectively; whence, for PbS (c), $Q_f = 24.8$ and 20.6 , respectively. Thomsen¹⁵ found $Q = 30.98$ for the reaction between aqueous lead nitrate and aqueous sodium sulfide; whence, for PbS (c), $Q_f = 22.5$. From equilibrium data, Jellinek and Zakowski¹ deduced $Q_f = 20.0$; Watanabe² obtained 22.85; Jellinek and Deubel,¹ 26.2.

PbSO₄ · nPbO (c). There has been a long polemic concerning the nature of the successive reactions occurring in the roasting of lead sulfate with lead sulfide, between Reinders^{1, 2, 3, 4} on the one hand and Schenck and coworkers (Schenck and Rassback,^{1, 2} Schenck and Borkenstein,¹ Schenck and Albers¹) on the other. See also Hofmann and Wanjukow.¹ According to Schenck and coworkers, the reactants for the various equilibrium curves are: PbSO₄ + PbS; PbSO₄ · PbO + PbS; PbSO₄ · 2 PbO + PbS; PbSO₄ · 3 PbO + PbS; PbO + PbS. This interpretation leads to the following values for the heats of formation: PbSO₄ · PbO (c), 280; PbSO₄ · 2 PbO (c), 340; PbSO₄ · 3 PbO (c), 398; PbO (c), 57. According to Reinders the reactants are: PbSO₄ + PbS; PbSO₄ · PbO + Pb; PbSO₄ · 2 PbO + Pb; PbSO₄ · 3 PbO + Pb; PbO + PbS. This interpretation yields the following values for *Qf*: PbSO₄ · PbO (c), 280; PbSO₄ · 2 PbO (c), 338; PbSO₄ · 3 PbO (c), 369; PbO (c), 51. In spite of the high value for PbO, we have accepted Schenck's as the more logical explanation of the equilibrium data obtained.

PbSO₄ · 2 HCl (c). Ephraim⁷ studied the dissociation pressure of this substance.

PbS₂O₃ (c). Fogh¹ found *Q* = 5.80 for the reaction between aqueous lead acetate and aqueous sodium thiosulfate to form an insoluble white product which was presumably lead thiosulfate. Hence, for PbS₂O₃ (c), *Qf* = 151.1.

PbS₃O₆ (c). Fogh¹ measured the heat of solution.

PbS₂O₆ · 4 H₂O (c). Thomsen¹⁵ measured the heat of solution.

PbSe (c). Fabre¹ found *Q* = 40.1 for the reaction of aqueous lead acetate with gaseous hydrogen selenide; whence, for PbSe (c), *Qf* = 21.2. For the heat of solution of crystalline lead selenide in saturated bromine water to form lead selenate Fabre¹ found 92.1; whence, for PbSe (c), *Qf* = 10.

PbSeO₄ (c). Metzner² found *Q* = 0.62 for the reaction of aqueous lead nitrate with aqueous sodium selenate; whence, for PbSeO₄ (c), *Qf* = 148.6.

PbTe (c). Fabre³ found 104.5 for the heat of solution of solid lead telluride in saturated bromine water. These data yield, for PbTe (c), *Qf* = 19.1 or 6.0, depending upon whether tellurate or tellurite was formed. Fabre³ said that the product was tellurite, but in another experiment he found that tellurium dissolved under the same conditions to form tellurate.

PbN₆ (c). Wohler and Martin¹ measured the heat of decomposition by explosion into solid lead and gaseous nitrogen to be 103.0.

Pb(NO₃)₂ · PbO (c). Thomsen's¹⁵ data on the reaction between aqueous lead nitrate and aqueous sodium hydroxide yield, for Pb(NO₃)₂ · PbO (c), *Qf* = 167.6.

PbX₂ · nNH₃ (c). Biltz and Fischer¹ measured at various temperatures the dissociation pressures of the ammines of PbCl₂ with 1, 1½, 2, 3½, and 8 moles of NH₃, of PbBr₂ with 1, 2, 3, 5½, and 8 moles of NH₃, and of PbI₂ with ½, 1, 2, 5, and 8 moles of NH₃. See also Ephraim.¹⁰

$2 \text{PbCl}_2 \cdot \text{NH}_4\text{Cl}$ (c). Brönsted⁸ determined, from electromotive force measurements, the heat of formation of this substance from solid lead chloride and solid ammonium chloride to be 0.35.

$3 \text{PbI}_2 \cdot 4 \text{NH}_4\text{I} \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heat of solution of the anhydrous salt and the hexadecahydrate.

$\text{PbSO}_4 \cdot (\text{NH}_4)_2 \text{SO}_4$ (c). Barre¹ found $Q=1.93$ for the heat of formation of this substance from solid lead sulfate and solid ammonium sulfate.

PbHPO_3 (c). Amat¹ found $Q=0.65$ for the heat of mixing Na_2HPO_3 (aq.) with $\text{Pb}(\text{NO}_3)_2$ (aq.).

$\text{SnI}_2 \cdot \text{PbI}_2 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the octahydrate.

$3 \text{PbI}_2 \cdot \text{SbI}_3 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the dodecahydrate.

$3 \text{PbI}_2 \cdot \text{PI}_3 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the dodecahydrate.

$3 \text{PbI}_2 \cdot \text{AsI}_3 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the dodecahydrate.

$3 \text{PbI}_2 \cdot \text{BiI}_3 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the dodecahydrate.

PbCO_3 (c). Thomsen¹⁵ found 6.11 for the heat of the reaction, $\text{Pb}(\text{NO}_3)_2(200) + \text{Na}_2\text{CO}_3(200) = \text{PbCO}_3(\text{c}) + 2 \text{NaNO}_3(200)$; whence, for $\text{PbCO}_3(\text{c})$, $Q_f=169.8$. Berthelot¹² found 5.04 and 5.72 for the above reaction with sodium and potassium carbonates respectively. Berthelot¹² believed the reaction took place in two steps: the formation of amorphous lead carbonate and then its crystallization. He deduced 4.2 for the heat of crystallization. Marshall and Bruzs¹ measured the heat of solution of $\text{PbCO}_3(\text{c})$ in 10 per cent aqueous nitric acid to be 1.69, whence for $\text{PbCO}_3(\text{c})$, $Q_f=168.0$.

$\text{PbCO}_3 \cdot n\text{PbO}$ (c). Marshall and Bruzs¹ measured the heat of solution in 10 per cent aqueous nitric acid of $\text{PbCO}_3 \cdot \text{PbO}(\text{c})$ to be 8.69. From equilibrium data, Centnerswer, Falk, and Awerbuch¹ calculated: for $3 \text{PbO}(\text{c}) + \text{CO}_2(\text{g}) = \text{PbCO}_3 \cdot 2 \text{PbO}(\text{c})$, $Q=25$; for $\text{PbCO}_3 \cdot \text{PbO}(\text{c}) + \text{CO}_2(\text{g}) = 2 \text{PbCO}_3(\text{c})$, $Q=-19.8$; and for $2 (\text{PbCO}_3 \cdot 2 \text{PbO})(\text{c}) + \text{CO}_2(\text{g}) = 3 (\text{PbCO}_3 \cdot \text{PbO})(\text{c})$, $Q=23$.

PbC_2O_4 (c). Berthelot¹² measured the heat of reaction between aqueous lead nitrate and aqueous potassium oxalate to be 9.3.

$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ (aq.). The data of Thomsen¹⁵ yield for the reactions, $\text{Zn}(\text{c}) + \text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2(400) = \text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2(400) + \text{Pb}(\text{c})$, and $\text{PbO}(\text{c}) + 2 \text{HC}_2\text{H}_3\text{O}_2(200) = \text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2(400) + \text{H}_2\text{O}(\text{liq.})$, $Q=34.90$ and 15.46 , respectively. From the known values for the other substances we have obtained, for $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2(400)$, $Q_f=236.0$ and 235.6 , respectively. The data of Herschkowitsch¹ and Aufenast and Terry¹ yield for the second reaction above $Q=15.50$ and 15.6 , respectively; whence, for $\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2(\text{aq.})$, $Q_f=235.7$ and 235.8 .

$\text{Pb}(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Berthelot⁹ measured the heat of solution.

Pb(C₂H₃O₂)₂ · 3 H₂O (c). The data on the heat of solution are: Berthelot,⁹ -5.5_{220}^{11} ; Favre and Silbermann,³ -4.9 ; Thomsen,¹⁵ -6.14_{200} .

Pb(C₂H₃O₂)₂ · PbO (c). Thomsen's¹⁵ data yield, for this substance, $Q_f = 292.9$.

Pb(CHO₂)₂ (aq.). Berthelot⁹ found 13.2 for the heat of neutralization of solid lead hydroxide with aqueous formic acid.

Pb(CHO₂)₂ (c). Berthelot⁹ measured the heat of solution of lead formate.

Pb(C₂H₃O₃)₂ (aq.). de Forcrand³ measured the heat of reaction of aqueous lead glycollate with aqueous hydrogen sulfide to be 11.5.

Pb(C₂H₃O₃)₂ (c). deForcrand³ measured the heat of solution of lead glycollate.

Pb(CN)₂ · 2 PbO · H₂O (c). Joannis¹ measured the heat of solution of this substance in aqueous nitric acid to be 36.8.¹⁹

Pb(CNS)₂ (c). Joannis¹ measured the heat of mixing aqueous lead acetate with aqueous potassium sulfocyanide to be 7.4.

PbSn (c). Magnus and Mannheimer¹ found the heat of formation of PbSn (c) to be 0.03 by measuring the heats of solution in mercury.

PbSn_n (liq.). Magnus and Mannheimer¹ measured the heat of mixing the two liquid metals.

PbSb_n (liq.). Guthrie and Libmans¹ discussed the data of Wust and Durrer¹ on the heat of mixing the liquid metals. See also Dobereiner¹ and Taylor.³

GALLIUM

Ga (c). Standard state.

Ga (g). We have estimated the heat of sublimation to be -52 . The somewhat uncertain vapor pressure data of Harteck² yield -50.9^{00} . The values for the various energy states of gaseous monatomic gallium are from the following: first spectra, Uhler and Tanch,¹ Paschen and Meissner¹; second spectra, Sawyer and Lang,¹ Lang,¹ and Rao, Narayan, and Rao¹; third spectra, Lang¹; fourth spectra, Mack, LaPorte and Lang.¹

GaCl₃ (aq.). Schwarz von Bergkampff¹ measured the heat of solution of Ga (c) in HCl (9) to be 32. We have estimated the value for the dilute solution.

Ga₂O₃ (c). Roth and Becker³ determined the heat of formation of this oxide by combustion of gallium in oxygen to be 255.8.

Ga⁺⁺⁺ (aq.). This value is obtained from that for aqueous gallium chloride.

INDIUM

In (c). Standard state.

In (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic indium are from the following: first spectra, Paschen and Meissner,¹ Uhler and Tanch¹; second spectra, Lang and Sawyer¹; third spectra, Rao, Narayan, and Nao.¹ See also Bacher and Goudsmit.¹

In₂O₃ (c). Ditte⁶ measured the heat of combustion of indium.

InCl₃ (aq.). Klemm and Brautigam¹ measured the heat of reaction of In (c) with Cl₂ (aq.).

In⁺⁺⁺ (aq.). The value for this substance is obtained from those for InCl₃ (aq.) and Cl⁻ (aq.).

InBr₃ (aq.), InI₃ (aq.). The values for these substances are obtained from those for the ions.

InCl (c), InCl₂ (c). Klemm and Brautigam¹ measured the heats of reaction of these substances, respectively, with aqueous chlorine to form aqueous InCl₃.

InCl₃ (c), InBr₃ (c), InI₃ (c). Klemm¹ measured the heats of solution of these substances in HCl (21).

InX₃ · nNH₃ (c). Klemm¹ measured the heats of solution in HCl (22) of the following: NH₃ (g), 12.3; InCl₃ · NH₃ (c), 15.4; InCl₃ · 2 NH₃ (c), 15.8; InCl₃ · 3 NH₃ (c), 16.8; InCl₃ · 5 NH₃ (c), 34.4; InBr₃ · 3 NH₃ (c), 17.3; InBr₃ · 5 NH₃ (c), 30.8; InBr₃ · 7 NH₃ (c), 54.6; InI₃ · 2 NH₃ (c), 14.0; InI₃ · 5 NH₃ (c), 27.7; InI₃ · 7 NH₃ (c), 46.4. Klemm¹ also determined from dissociation pressure data the heats of dissociation of the following: InCl₃ with 1, 2, 3, 5, 7, and 15 moles of NH₃; InBr₃ with 5, 6, and 15 moles of NH₃; InI₃ with 1, 9, and 15 moles of NH₃.

THALLIUM

Tl (c, II). Standard state.

Tl (c, I). The heat of transition at 226° was determined by Bridgman,^{7, 8} Werner,² and Umino.¹

Tl (liq.). The data on the heat of fusion of thallium yield the following values: Heycock and Nevilles,¹ -1.05; Robertson,¹ -1.47; Richards and Smyth,¹ -1.52; Lewis and Randall,⁴ -1.45; Roos,¹ -1.52. See also Umino.¹

Tl (g). We have assumed that gaseous thallium is monatomic. Vapor pressure data were reported by Gibson,¹ Krafte and Knocke,¹ von Wartenberg,⁹ and Fischer and Geiger¹ (see Sherman¹). These data yield values for the heat of sublimation ranging from -28 to -45. Butkow¹ and Butkow and Terenin¹ reported -81 for the heat of reaction TlII (g) = Tl (g) + I* (g); whence, for Tl (g), $Q_f = -35.9$. Similar data on TlCl (g) and TlBr (g) yield, for Tl (g), $Q_f = -41.9$ and -37.5 , respectively. The values of Mayer² for the lattice energies of TlCl, TlBr, and TlI yield, for Tl (g), $Q_f = -38.6$, -43.4 , and -40.2 .

The values for the energy states of gaseous monatomic thallium are from Fowler,³ McLennan, McLay, and Crawford,¹ Carroll,¹ and Smith.³

Tl₂SO₄ (aq.). Thomsen¹⁵ measured the heats of solution of Tl (c, II) and of Tl₂SO₄ (c) in H₂SO₄ (50), and of Tl₂SO₄ (c) in water. His data yield for Tl₂SO₄ (1600), $Q_f = 213.7$. Data on the heat of dilution of aqueous thallous sulfate were reported by Thomsen¹⁵ and deForcrand.⁷¹

Tl₂SO₄ (c). The data on the heat of solution in water are: Cohen and Kooy,¹ -7.94_{3200}^{20} ; Thomsen,¹⁵ -8.28_{1600} . See also Ishikawa.^{1, 2}

TlOH (aq.). Thomsen¹⁵ measured the heat of neutralization of 2 TlOH (200) with H₂SO₄ (400) to be 31.12₈₀₀. See also deForcrand.⁷¹

Tl₂O₃ (c). From equilibrium studies, Duncan² computed $Q^{1000} = -77$ for the reaction Tl₂O₃ (liq.) = Tl₂O (liq.) + O₂ (g). From these data we have estimated, for Tl₂O₃ (c), $Q_f = 120$. See also Roth and Becker.³

TlOH (c). Thomsen¹⁵ found $S = -3.15$. See also Aufenast and Terrey.¹

Tl₂O (c). Thomsen¹⁵ found $S = -3.08$, whence, for Tl₂O (c), $Q_f = 42.3$. From equilibrium data, Bahr¹ computed $Q = -14.1$ for the reaction, 2 TlOH (c) = Tl₂O (c) + H₂O (g); whence, for Tl₂O (c), $Q_f = 42.0$.

TlCl (c). The accurate electromotive force data of Gerke¹ yield for, TlCl (c), $Q_f = 48.62$. Combination of the data of Thomsen¹⁵ on the heat of neutralization of TlOH (aq.) with HCl (aq.) and the heat of solution of TlCl (c), yields, for the latter, $Q_f = 48.95$. See also Blaszkewska.¹

TlCl (aq.). The data on the heat of solution of TlCl (c) are: Thomsen,¹⁵ -10.0 ; Butler and Hiscock,¹ -10.56 .

TlCl (liq.). Roos¹ reported -3.95^{430} for the heat of fusion.

TlCl (g). The vapor pressure data of von Wartenberg and Bosse¹ yield -25.2^{806} for the heat of vaporization; whence, for TlCl (g), $Q_f = 16.4$.

TlF (aq.). de Forcrand⁶⁹ measured the heats of solution of Tl₂O (c) and TlOH (c) in HF (600) to be 28.33¹³ and 25.21¹³, respectively. Petersen¹ measured the heat of neutralization of TlOH (400) with HF (400) to be 16.44. These data yield, for TlF (800), $Q_f = 76.8$ and 77.5, respectively. If excess HF (aq.) was present in de Forcrand's experiments, the value from his data should be increased by 0.58.

TlF (c). There are no data on the heat of solution of thallous fluoride.

TlF (g). The vapor pressure data of von Wartenberg and Bosse¹ yield -25.1^{298} for the heat of vaporization.

TlBr (c). Thomsen¹⁵ measured the heat of reaction of Tl₂SO₄ (aq.) with KBr (aq.), his data yielding, for TlBr (c), $Q_f = 41.48$.

TlBr (liq.). Roos¹ reported $F = -3.6^{456}$. See also Mellor.¹

TlBr (g). The vapor pressure data of von Wartenberg¹ yield -25.2^{817} for the heat of vaporization, whence, for TlBr (g), $Q_f = 9.5$.

TlI (c). Thomsen's¹⁵ data on the reaction of Tl₂SO₄ (aq.) with HI (aq.) yield, for TlI (c), $Q_f = 31.16$. The electromotive force data of Jones and Schumb¹ yield $Q_f = 29.2$, but there may be some doubt concerning the reaction.

TlI (g). The vapor pressure data of von Wartenberg and Bosse¹ yield $V = -25.3^{818}$, whence, for TlI (g), $Q_f = -0.6$. See also Terenin.¹

TlNO₃ (aq.). For the heat of neutralization of TlOH (aq.) with HNO₃ (aq.), Thomsen¹⁵ found $Q = 13.70$, whence, for TlNO₃ (aq.), $Q_f = 48.2$.

TlNO₃ (c, III). Thomsen¹⁵ found $S = -10.0$.

TlNO₃ (c, II). Bridgman^{6a} reported, for the transition III to II, $T = -0.24^{75}$.

TlNO₃ (c, I). Bridgman^{6a} reported, for the transition II to I, $T = -0.76^{145}$.

TlN₃ (c). Wohler and Martin¹ found the heat of decomposition of thallium azide to be 54.7.

Tl₂S (c). Thomsen¹⁵ and Sabatier¹ reported the same value, 33.7, for the heat of the reaction, $2 \text{TlNO}_3(200) + \text{Na}_2\text{S}(200) = \text{Tl}_2\text{S}(\text{c}) + 2 \text{NaNO}_3(300)$.

TlC₂H₃O₂ (aq.). de Forcrand⁶⁹ found 13.99 for the heat of neutralization of TlOH (aq.) with aqueous acetic acid; whence, for aqueous thalious acetate, $Q = 117.4$. From the ions, we have obtained $Q_f = 117.0$.

Tl₂Se (c). Fabre⁶ measured the heat of reaction between aqueous thalious acetate and gaseous H₂Se to be 41.2, and the heat of solution of Tl₂Se (c) in bromine water to be 143.5. These data yield, for Tl₂Se (c), $Q_f = 20.6$ and 11.0, respectively.

Tl₂Te (c). Fabre⁶ measured the heat of solution of Tl₂Te (c) in bromine water to be 159.5; whence, for Tl₂Te (c), $Q_f = 7.2$.

TlONC (c). Wohler and Martin¹ found the heat of decomposition of thallium fulminate to be 52.5, the products being CO (g), $\frac{1}{2}$ N₂ (g), and Tl (c).

TlX · nNH₃ (c). Biltz and Stollenwerk¹ determined the heats of dissociation of the triammines of TlCl, TlBr, and TlI.

Tl₂SO₄ · 10NH₃ (c). Ephraim and Millman¹ reported $D = -13.3$, but the products are not known.

TlC₂H₅O (C₂H₅OH). de Forcrand^{71, 71a} computed $Q = -10.4$ for the reaction, $\text{Tl}(\text{c}) + \text{C}_2\text{H}_5\text{OH}(\text{liq.}) = \text{TlC}_2\text{H}_5\text{O}(\text{C}_2\text{H}_5\text{OH}) + \frac{1}{2} \text{H}_2(\text{g})$, but the experimental data were not reported.

TlBr₃ (aq.). Thomsen¹⁵ reported $Q = 36.50$ for the reaction, $\text{TlBr}_3(\text{aq.}) + \text{SO}_2(200) = \text{TlBr}(\text{c}) + 2 \text{HBr}(200) + \text{H}_2\text{SO}_4(300)$; whence, for TlBr₃ (aq.), $Q_f = 58.1$.

Tl⁺⁺⁺ (aq.). The value for this substance is obtained from those for TlBr₃ (aq.) and Br⁻ (aq.).

TlX₃ · nH₂O (c). Thomas¹ measured the following heats of solution: TlCl₃, 8.43₃₀₀; TlCl₃ · 4 H₂O (c), -2.12₃₀₀; TlBr₃ · 4 H₂O (c), -2.25₅₀₀; TlBr₂Cl · 4 H₂O (c), -2.90₃₀₀.

ZINC

Zn (c). Standard state. Laschtschenko⁹ reported a transition in solid zinc at 320° with $T = -0.19$, but modern evidence points to but one form of crystalline zinc.

Zn (liq.). The data on the heat of fusion of zinc at its melting point, 419°, are: Mazzotto,¹ -1.83; Glaser,¹ -1.73; Iitaka,¹ -1.50; Wust,¹ -1.85; Person,² -1.79; Awbery and Griffiths,¹ -1.74; Umino,³ -1.54; Heycock and Neville,² -1.85. See also Richards¹ and Laschtschenko.⁸

Zn (g). According to the vapor density data of Biltz⁷ and von Wartenberg,⁸ gaseous zinc is practically monatomic. The vapor pressure

data of Barnes,^{1, 2} Richards,² Ruff and Bergdahl,¹ Braunes,¹ Deckert,¹ Greenwood,^{3, 6} Rodebush and Dixon,¹ Egerton,¹ and Jenkins³ yield -27.4 for the heat of sublimation, and -25.9 for the heat of vaporization, at 18° . Millar¹ computed -27.2 for the heat of sublimation. The direct calorimetric measurements of Whnelt and Muscelleanii,¹ Muscelleanii,¹ and Tate¹ yield -26.3 for the heat of vaporization.

The energy states of gaseous monatomic zinc are from Saunders,¹ Sawyer and Beese,¹ Wolff,¹ Fowler,³ Salis,¹ Fues,¹ Kayser and Runge,² and Paschen.^{1, 2, 3, 5}

Zn₂ (g). The spectroscopic data of Winans² yield $D^\circ = -5.67$. See also Mrozowski.¹

ZnCl₂ (aq.). The following are the data on the heat of the reaction, $\text{Zn (c)} + 2 \text{HCl (n)} = \text{ZnCl}_2 (2n) + \text{H}_2 (\text{g})$: Richards and Thorvaldson,¹ HCl (200) , $Q = 36.55$; Richards, Rowe, and Burgess,⁷ HCl (200) , $Q = 36.6$; Thomsen,¹⁵ HCl (100) , $Q = 34.20$; Hess,¹⁰ $Q = 34.9$; Favre and Silbermann,³ $Q = 33$; Richards and Thorvaldson,¹ HCl (20) , $Q = 32.79^{20}$; Maier,⁵ HCl (20) , $Q = 32.19$; Sieverts and Gotta,² HCl (20) , $Q = 31.1^{19}$; Hablutzel,¹ HCl (20) , $Q = 31.5$; Biltz and Wagner,¹ HCl (20) , $Q = 30.06$; Sieverts and Gotta,³ HCl (20) , $Q = 30.28$; Biltz and Hohorst,¹ HCl (20) , $Q = 30.15$; Sommermeier,¹ HCl (20) , $Q = 30.43$; Biltz and Hohorst,¹ HCl (8) , $Q = 33.55$. The heat of dilution of aqueous zinc chloride was measured by Thomsen,¹⁵ and computed from vapor pressure-temperature data by Fricke and Havestadt.¹

ZnSO₄ (aq.). Thomsen¹⁵ measured the heats of the reactions, $\text{ZnSO}_4 (400) + \text{BaCl}_2 (400) = \text{BaSO}_4 (\text{c}) + \text{ZnCl}_2 (800)$ and $\text{H}_2\text{SO}_4 (400) + \text{BaCl}_2 (400) = \text{BaSO}_4 (\text{c}) + 2 \text{HCl (400)}$, to be 5.50 and 9.15, respectively. The difference gives $Q = -3.65$ for the reaction, $\text{ZnSO}_4 (400) + 2 \text{HCl (400)} = \text{H}_2\text{SO}_4 (400) + \text{ZnCl}_2 (800)$; whence, for $\text{ZnSO}_4 (400)$, $Q_f = 251.95$. de Forcrand⁸ measured the heat of solution of zinc in aqueous sulfuric acid and his data yield, for $\text{ZnSO}_4 (200)$, $Q_f = 247$. See also Ditte⁵ and Hess.¹⁰ The heat of dilution of aqueous zinc sulfate was measured by Thomsen,¹⁵ Berthelot,⁵ and de Forcrand.⁸

ZnSO₄ (c). The data on the heat of solution of zinc sulfate in water are: Thomsen,¹⁵ 18.54₄₀₀; Mees,¹ 18.27₄₀₀.

ZnSO₄ · nH₂O (c). Thomsen¹⁵ found the heat of solution of the monohydrate to be -10.0 . (He also gave values for the tri- and tetrahydrates but the heat of solution-composition curve shows no breaks at these points to indicate definite hydrates.) For the hexahydrate, Thomsen¹⁵ found $S = -0.84$. For the heptahydrate, the heat of solution data are: Thomsen,¹⁵ -4.28_{400} ; Mees,¹ -4.26_{400} ; Favre and Silbermann,³ -3.76 . The dissociation pressure data of Frowein,¹ Muller and Erzback,⁴ and Rolla and Accame¹ yield the following results: $\text{ZnSO}_4 \cdot 7 \text{H}_2\text{O (c)} = \text{ZnSO}_4 \cdot 6 \text{H}_2\text{O (c)} + \text{H}_2\text{O (g)}$, $Q = -13.26$; $\text{ZnSO}_4 \cdot 6 \text{H}_2\text{O (c)} = \text{ZnSO}_4 \cdot 5 \text{H}_2\text{O (c)} + \text{H}_2\text{O (g)}$, $Q = 5 (-13.36)$; $\text{ZnSO}_4 \cdot \text{H}_2\text{O (c)} = \text{ZnSO}_4 (\text{c}) + \text{H}_2\text{O (g)}$, $Q = -15.2$. See also Foote and Scholes,¹ Lescoeur,¹ Wiedemann,¹ and Ishikawa and Murooka.¹ From electromotive force measure-

ments, Cohen and Inouye¹ found $Q = 3.605^{39}$ for the reaction $\text{ZnSO}_4 \cdot 7 \text{H}_2\text{O} (\text{c}) = \text{ZnSO}_4 \cdot 6 \text{H}_2\text{O} (\text{c}) + \text{H}_2\text{O} (\text{aq. satd. soln.})$.

$\text{Zn}^{++} (\text{aq.})$. We have obtained the value for this substance from those for $\text{ZnCl}_2 (\text{aq.})$ and $\text{ZnSO}_4 (\text{aq.})$. See also Getman and Gibbons¹ and Latimer.²

$\text{ZnO} (\text{c.})$. The heat of solution of unfused zinc oxide in aqueous hydrochloric acid was measured by Favre and Silbermann,³ Hess,¹⁰ Maier,⁵ Parks, Hablutzel, and Webster,¹ and Maier, Parks, and Anderson.¹ Apparently, the heat of solution of unfused zinc oxide is independent of the manner of its preparation. These data yield, for $\text{ZnO} (\text{c, unfused})$, $Q_f = 83.5$. Ditté,⁵ de Forcrand^{8, 9, 40, 41, 42} and Marignac¹ measured the heat of solution of zinc oxide in aqueous sulfuric acid. Their data yield, for $\text{ZnO} (\text{c, unfused})$, $Q_f = 83.7$, and for $\text{ZnO} (\text{c, fused})$, $Q_f = 85.5$. See also Woods,¹ Berthelot,^{141, 142} and Theis.¹ Parr and Moose¹ measured the heat of combustion of zinc to form fused zinc oxide to be 85.2. See also the old values of Dulong,¹ Andrews,^{14, 15} and Despretz.²

$\text{ZnH} (\text{g.})$. The energy of dissociation of gaseous zinc hydride, in the normal state, into gaseous zinc and hydrogen atoms, each in the normal state, was reported by Fukuda¹ and Bengtsson and Hulthen¹ from their spectroscopic data. The values for the higher energy states of gaseous ZnH are taken from the foregoing authors and from Grundstrom.¹

$\text{Zn}(\text{OH})_2 (\text{c, ppt.})$. Thomsen¹⁵ measured the heat of reaction of aqueous zinc sulfate with aqueous barium hydroxide and aqueous potassium hydroxide, and his data yield for $\text{Zn}(\text{OH})_2 (\text{c, ppt.})$, $Q_f = 155.3$. de Forcrand⁸ measured the heat of solution of $\text{Zn}(\text{OH})_2 (\text{c, ppt.})$ in $\text{H}_2\text{SO}_4 (200)$ to be 18.9, which gives $Q_f = 155.3$. See also Mixter.¹¹

$\text{Zn}(\text{OH})_2 (\text{c, not ppt.})$. The electromotive force data of Maier, Parks, and Anderson¹ yield for this substance $Q_f = 155.84$, but the cell reaction may be somewhat uncertain.

$\text{Zn}(\text{OH})_2 \cdot \text{H}_2\text{O} (\text{c, ppt.})$. de Forcrand⁸ measured the heat of solution of this substance in $\text{H}_2\text{SO}_4 (200)$.

$\text{ZnO}_2 \cdot 2 \text{H}_2\text{O} (\text{c.})$. de Forcrand⁸ measured the heat of solution in $\text{H}_2\text{SO}_4 (200)$.

$\text{Zn}_3\text{O}_5 \cdot n \text{H}_2\text{O} (\text{c.})$. de Forcrand⁸ measured the heats of solution of the di- and trihydrates in $\text{H}_2\text{SO}_4 (200)$.

$\text{ZnF}_2 (\text{aq.})$. Petersen¹ measured the heat of the reaction of aqueous zinc chloride with solid silver fluoride to be 31.84. Mulert¹ measured the heat of solution of ZnO in aqueous (20%) HF to be 21.82. See also Jellinek and Rudat.¹

$\text{ZnCl}_2 (\text{c.})$. The data on the heat of solution of solid zinc chloride in water are: Thomsen,¹⁵ 15.72₄₀₀; Pickering,⁸ 15.22₄₀₀; Baud,¹ 15.89₄₀₀¹⁵; Ishikawa and Murooka,¹ 16.71₄₀₀. See also Andrews¹⁶ and Favre and Silbermann.³ The use of Thomsen's value yields, for $\text{ZnCl}_2 (\text{c.})$, $Q_f = 99.6$. The data of Klemm and Brautigam,¹ who measured in an ice calorimeter the heats of solution of $\text{Zn} (\text{c.})$, $\text{Cl}_2 (\text{g.})$, and $\text{ZnCl}_2 (\text{c.})$, in aqueous (33%) KBr containing excess liquid Br_2 , yield, for $\text{ZnCl}_2 (\text{c.})$, $Q_f = 99.8$. The

electromotive force data of Foxton and Shutt,¹ on the cell in which the reaction was $\text{Zn (c)} + \text{Cl}_2 \text{ (g)} = \text{ZnCl}_2 \text{ (11.11)}$, give $Q^{70} = 105.4$.

$\text{ZnCl}_2 \cdot (\text{C}_2\text{H}_5\text{OH})$. Pickering⁸ measured the heat of solution of zinc chloride in ethyl alcohol.

$\text{ZnCl}_2 \cdot n\text{ZnO} \cdot n'\text{H}_2\text{O (c)}$. Andre¹ measured the heats of solution of $\text{ZnCl}_2 \cdot 3\text{ZnO} \cdot 5\text{H}_2\text{O (c)}$, $\text{ZnCl}_2 \cdot 4\text{ZnO} \cdot 11\text{H}_2\text{O (c)}$, $\text{ZnCl}_2 \cdot 5\text{ZnO} \cdot 8\text{H}_2\text{O (c)}$, and $\text{ZnCl}_2 \cdot 8\text{ZnO} \cdot 10\text{H}_2\text{O (c)}$.

$\text{ZnBr}_2 \text{ (aq.)}$. The value for this substance is obtained from those for the ions, and by analogy with $\text{ZnCl}_2 \text{ (aq.)}$.

$\text{ZnBr}_2 \text{ (c)}$. The data on the heat of solution of zinc bromide are: Thomsen,¹⁵ 15.02₄₀₀; Andre,¹ 13.8⁵. The use of Thomsen's value gives, for $\text{ZnBr}_2 \text{ (c)}$, $Q_f = 78.3$. From electromotive force data, Ishikawa and Yoshida¹ computed, for $\text{ZnBr}_2 \text{ (c)}$, $Q_f = 78.47$. See also Czepinski² and Andrews.³

$\text{ZnBr}_2 \cdot 4\text{ZnO} \cdot 13\text{H}_2\text{O (c)}$. Andre¹ measured the heat of solution.

$\text{ZnI}_2 \text{ (aq.)}$. The value for this substance is obtained from those for the ions, and by analogy with $\text{ZnCl}_2 \text{ (aq.)}$, to be 62.3 for $\text{ZnI}_2 \text{ (600)}$. Webb^{1,2} measured the heat of solution of zinc in iodine water to form $\text{ZnI}_2 \text{ (650)}$, and computed, for the latter, $Q_f = 61.4$.

$\text{ZnI}_2 \text{ (c)}$. Webb^{1,2} measured the heat of solution of zinc iodide in water to be 11.6₆₅₀, whence, for ZnI (c) , $Q_f = 49.8$. See also Andrews.² Mosnier¹ found $S = 11.4$. Webb's^{1,2} data on the cell in which $\text{ZnI}_2 \text{ (c)}$ was formed from its elements gave $Q_f = 49.90$. Similar data by Ishikawa and Shibata¹ yield $Q_f = 51.2$.

$\text{ZnI}_2 \cdot 5\text{ZnO} \cdot 11\text{H}_2\text{O (c)}$. Tassilly¹ measured the heat of solution in aqueous HI to be 115.6.

ZnI (g) . Sponer⁴ estimated $D^z = -46$, from spectroscopic data, for the dissociation into gaseous normal zinc and iodine atoms. Wieland¹ reported a value for the energy of the excited state of gaseous ZnI .

$\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \text{ (aq.)}$. Thomsen¹⁵ measured the heat of the reaction of aqueous barium acetate and zinc sulfate, $\text{Ba}(\text{C}_2\text{H}_3\text{O}_2)_2 \text{ (200)} + \text{ZnSO}_4 \text{ (200)} = \text{BaSO}_4 \text{ (c)} + \text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \text{ (400)}$, to be 4.61; whence, for $\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \text{ (400)}$, $Q_f = 270.9$. Berthelot⁵ measured the heat of reaction of aqueous zinc acetate with aqueous sodium hydroxide to be 10.8. See also Favre and Silbermann.³ The heat of dilution of aqueous zinc acetate was measured by Thomsen.¹⁵ See also Berthelot.⁵

ZnS (c) . Thomsen¹⁵ measured the heat of reaction of aqueous zinc sulfate with aqueous sodium sulfide, his data yielding, for ZnS (c, ppt.) , $Q_f = 44.3$. The data of Mixter,¹⁵ who measured in a bomb calorimeter the reaction of ZnS with Na_2O_2 , yield, for $\text{ZnS (c, zinc blende)}$, $Q_f = 41.3$. See also Berthelot¹⁴ and Jellinek and Zakowsky.¹

$\text{ZnS}_2\text{O}_4 \text{ (aq.)}$. Berthelot measured the heat of oxidation with oxygen of an aqueous solution containing zinc, sodium, and, presumably, hydro-sulfite ions, to be 67.8.

$\text{ZnS}_2\text{O}_6 \cdot 6\text{H}_2\text{O (c)}$. Thomsen¹⁵ measured the heat of solution.

ZnSe (c) . Fabre⁸ measured the heat of reaction of aqueous zinc ace-

tate with gaseous H_2Se and aqueous Na_2Se to be 23.3 and 32.7, respectively, whence, for ZnSe (c), $Q_f = 39.6$ and 34.6. Fabre³ also measured the heat of the reaction of zinc selenide with water and bromine to be 100.0; whence, for ZnSe (c), $Q_f = 33.4$.

ZnTe (c). Fabre³ measured the heat of the reaction of zinc telluride with water and bromine, and his data yield, for ZnTe (c), $Q_f = 33$.

ZnN_6 (c). Wohler and Martin¹ measured the heat of decomposition of zinc azide into Zn (c) and 3N_2 (g) to be 50.8.

$\text{Zn}(\text{NO}_3)_2$ (aq.). Thomsen¹⁵ measured the heat of reaction of $\text{Zn}(\text{OH})_2$ (c, ppt.) with aqueous nitric acid to form $\text{Zn}(\text{NO}_3)_2$ (400), to be 19.83. The heat of dilution of aqueous zinc nitrate was measured by Thomsen.¹⁵ We have extrapolated the values to $3 \text{H}_2\text{O}$.

$\text{Zn}(\text{NO}_3)_2 \cdot n\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution of hexahydrate. Morgan and Owens¹ determined the heat of fusion of the trihydrate.

$\text{ZnF}_2 \cdot 2 \text{H}_2\text{O} \cdot n\text{NH}_3$ (c). Biltz and Ralphs² reported $Q = 2\frac{1}{2}$ (11.2) for the dissociation, $\text{ZnF}_2 \cdot 2 \text{H}_2\text{O} \cdot 3 \text{NH}_3$ (c) = $\text{ZnF}_2 \cdot 2 \text{H}_2\text{O} \cdot \frac{1}{2} \text{NH}_3$ (c) + $2\frac{1}{2} \text{NH}_3$ (g).

$\text{ZnX}_2 \cdot n\text{NH}_3$ (c). Biltz and Messerknecht¹ obtained dissociation pressure-temperature data on the amines of ZnCl_2 with 1, 2, 4, 6, and 10 NH_3 , on those of ZnBr_2 with 1, 2, 4, and 6 NH_3 , and on those of ZnI_2 with 1, 2, 4, and 6 NH_3 . Ephraim⁹ obtained similar data on the hexamines of ZnCl_2 and ZnBr_2 . Isambert⁵ measured the heat of solution of the decamine of ZnCl_2 in aqueous HCl ; Biltz and Messerknecht¹ those of the di-, tetra- and hexamines of ZnCl_2 ; Tassilly¹ those of the tetramines of ZnBr_2 and ZnI_2 and the diammine of ZnI_2 .

$\text{Zn}(\text{XO}_3)_2 \cdot n\text{NH}_3$ (c). Ephraim and Jahnsen¹ obtained dissociation pressure data on $\text{Zn}(\text{ClO}_3)_2 \cdot 4 \text{NH}_3$ (c), $\text{Zn}(\text{ClO}_3)_2 \cdot 6 \text{NH}_3$ (c), and $\text{Zn}(\text{IO}_3)_2 \cdot 4 \text{NH}_3$ (c). Ephraim and Bolle¹ obtained similar data on the tetra- and hexamines of zinc chlorate.

$\text{Zn}(\text{ClO}_4)_2 \cdot 6 \text{NH}_3$ (c). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{Zn}(\text{NO}_3)_2 \cdot n\text{NH}_3$ (c). Ephraim and Bolle¹ measured the dissociation pressure at various temperatures of the tetra- and hexamines of zinc nitrate.

$\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2 \text{NH}_3$ (c). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{Zn}(\text{NO}_2)_2 \cdot \text{NH}_3$ (c). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{ZnSO}_3 \cdot 3 \text{NH}_3$ (c). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{ZnS}_2\text{O}_6 \cdot 4 \text{NH}_3 \cdot \text{H}_2\text{O}$ (c). Ephraim and Bolle¹ obtained dissociation pressure data.

$\text{Zn}(\text{CNS})_2 \cdot n\text{NH}_3$ (c). Ephraim and Bolle¹ obtained dissociation pressure data on the tetra- and hexamines of $\text{Zn}(\text{CNS})_2$.

$\text{ZnS}_2\text{O}_6 \cdot 5 \text{NH}_3$ (c.). Ephraim and Bolle¹ obtained dissociation pressure data.

$\text{ZnS}_4\text{O}_6 \cdot 5 \text{NH}_3$ (c.). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{ZnS}_2\text{O}_3 \cdot 5 \text{NH}_3$ (c.). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{Zn}(\text{CHO}_2)_2 \cdot 5 \text{NH}_3$ (c.). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{ZnC}_2\text{O}_4 \cdot 5 \text{NH}_3$ (c.). Ephraim and Bolle¹ measured the dissociation pressures.

$\text{ZnCl}_2 \cdot 5 \text{NH}_3 \cdot \text{H}_2\text{O}$ (c.). Andre¹ measured the heat of solution in $\text{HCl}(100)$.

$\text{ZnCl}_2 \cdot 2 \text{NH}_3 \cdot \frac{1}{4} \text{H}_2\text{O}$ (c.). Andre¹ measured the heat of solution in $\text{HCl}(100)$.

$\text{ZnCl}_2 \cdot 8 \text{NH}_4\text{Cl} \cdot \text{ZnO}$ (c.). Andre¹ measured the heat of solution in $\text{HCl}(100)$.

$3 \text{ZnCl}_2 \cdot 6 \text{NH}_4\text{Cl} \cdot \text{H}_2\text{O}$ (c.). Andre¹ measured the heat of solution in $\text{HCl}(100)$.

$3 \text{ZnCl}_2 \cdot \text{ZnO} \cdot 10 \text{NH}_4\text{Cl}$ (c.). Andre¹ measured the heat of solution.

$6 \text{ZnCl}_2 \cdot \text{ZnO} \cdot 12 \text{NH}_3$ (c.). Andre¹ measured the heat of solution.

$\text{ZnSO}_4 \cdot n \text{NH}_3$ (c.). The values for the ammines of zinc sulfate with $\frac{1}{2}$, 1, 2, 3, 4, and 5 NH_3 are taken from the work of Ephraim^{8, 10} and Ephraim and Bolle.¹

$\text{Zn}(\text{NH}_4)_2(\text{SO}_4)_2 \cdot n \text{H}_2\text{O}$ (c.). Graham² measured the heat of solution of the hexahydrate. Caven and Ferguson² measured the dissociation pressures of the system containing the hexahydrate, dihydrate, and water vapor.

$\text{Zn}(\text{NH}_4)_2(\text{SeO}_4)_2 \cdot 6 \text{H}_2\text{O}$ (c.). Caven and Ferguson² measured the dissociation pressure to the dihydrate.

$\text{Zn}(\text{C}_2\text{H}_5)_2$ (liq.). Guntz⁹ measured the heat of solution of liquid zinc ethyl in aqueous sulfuric and hydrochloric acids to be 79.8 and 78.0, respectively. Correcting for the heat of mixing gives, for $\text{Zn}(\text{C}_2\text{H}_5)_2$ (liq.), $Q_f = 10.0$.

$\text{ZnC}_2\text{O}_4 \cdot 2 \text{H}_2\text{O}$ (c.). Berthelot¹⁰ reported the heat of the reaction, $\text{Zn}(\text{OH})_2(\text{c}) + \text{H}_2\text{C}_2\text{O}_4(\text{aq.}) = \text{ZnC}_2\text{O}_4 \cdot 2 \text{H}_2\text{O}(\text{c})$, to be $Q = 25.0$. This was derived from his unpublished figures on the reaction between zinc sulfate and potassium oxalate.

ZnCO_3 (c.). Berthelot's¹² data on the heats of reaction of aqueous zinc sulfate with aqueous sodium carbonate and aqueous potassium carbonate yield, for ZnCO_3 (c), $Q_f = 192.4$ and 194.2.

$\text{Zn}(\text{CHO}_2)_2$ (aq.). Berthelot^{9, 131} reported a value for the heat of neutralization of formic acid with zinc hydroxide.

$\text{Zn}(\text{CHO}_2)_2$ (c.). Berthelot^{9, 131} measured the heat of solution of zinc formate.

$\text{Zn}(\text{CHO}_2)_2 \cdot 2 \text{H}_2\text{O}$ (c.). Berthelot^{9, 131} measured the heat of solution of the dihydrate.

$\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Berthelot^{9, 131} measured the heat of solution of zinc acetate.

$\text{Zn}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot n\text{H}_2\text{O}$ (c). Berthelot^{9, 131} measured the heats of solution of the mono- and dihydrates.

$\text{Zn}(\text{C}_2\text{H}_3\text{O}_3)_2$ (aq.). de Forcrand³ measured the heat of reaction of zinc sulfate with barium glycollate.

$\text{Zn}(\text{C}_2\text{H}_3\text{O}_3)_2 \cdot n\text{H}_2\text{O}$ (c). de Forcrand³ measured the heats of solution of the anhydrous zinc glycollate and of the dihydrate.

$\text{Zn}(\text{CN})_2$ (c). Joannis¹ and Berthelot¹¹⁴ measured the heat of precipitation of zinc cyanide. We have used the data of Joannis.

$\text{Zn}(\text{CN})_4^-$ (aq.). Berthelot measured the heat of solution of $\text{Zn}(\text{CN})_2$ (c) in aqueous KCN to be 8.6.

ZnSiO_3 (c). Mulert¹ measured the heat of solution in aqueous 20% HF.

Zn_2SiO_4 (gls.). Mulert¹ measured the heat of solution in aqueous 20% HF.

Zn_2SiO_4 (c). Mulert¹ measured the heat of solution in aqueous 20% HF.

ZnSn_n (c). Herschowitz² computed the heats of formation of the solid alloys, ZnSn_2 , $\text{ZnSn}_{0.6}$, $\text{ZnSn}_{0.21}$, and $\text{ZnSn}_{0.1}$, from his data on heats of solution in bromine water. See also Magnus and Mannheimer.¹

$2\text{ZnI}_2 \cdot \text{PbI}_2$ (c). Mosnier¹ measured the heat of solution.

CADMIUM

Cd (c). The hexagonal form is taken as the standard state. Getman¹ found $T = -0.055$ for the transition from II to I at 37.5° . Cohen and Heldermaun,^{1, 3} reported a transition from III to II at 18° with $T = -0.74$, but the X-ray and other data of Getman¹ can not be reconciled to the existence of a third form of cadmium.

Cd (liq.). The data on the heat of fusion of cadmium at its melting point, 321° , are: Umino,³ -1.45 ; Wust, Meuthen and Durrer,¹ -1.23 ; Person,¹ -1.54 ; Richards,¹ -1.48 ; Johnston and Adams,² -1.54 ; Roos,² -1.49 .

Cd (g). Vapor pressure data for cadmium were reported by Maier,³ Egerton,¹ Jenkins,³ Barus,^{1, 2} Ruff and Bergdahl,¹ Braune,¹ Fogler and Rodebush,¹ Bennewitz,¹ and Weber.¹ By direct measurement, Wehnelt and Muscelleanii¹ obtained the value -20.4 for the heat of vaporization of liquid cadmium. Calculations of the heat of vaporization were made by Johnston,⁶ van Liempt,² Hildebrand,² Millar,¹ and Maier.³ Maier's³ equation yields, for Cd (g), $Q_f = -26.8$. The vapor density data of Biltz⁷ and Deville and Troost¹ indicate that gaseous cadmium is practically monatomic, as do the entropy calculations of Tolman,¹ Fogler and Rodebush,¹ and Lange and Simon.¹

The energy states of gaseous monatomic cadmium are evaluated from the work of Fowler,³ Fues,¹ and Salis.¹

Cd₂ (g). The spectroscopic data of Winans^{1, 2} gave $D^\circ = -5$, while

the later work of Kuhn and Arrhenius¹ gave $D^{\circ} = -46$. See also Mrozowski.²

CdCl₂ (aq.). The data on the heat of solution of Cd (c) in 2HCl(200) are: Thomsen,¹⁵ 17.61; Richards, Rowe, and Burgess,¹ 17.12; Richards and Tamaru,¹ 17.15. Data on the heat of dilution of aqueous cadmium chloride were obtained by Thomsen.¹⁵ The value, $Q = -0.062$, reported by Cohen and Bruins³ for the dilution from 9.192 to 400 H₂O seems unreasonable.

CdCl₂ (c). The data on the heat of solution of cadmium chloride are: Cohen and Bruins,³ 3.09₄₀₀; Thomsen,¹⁵ 3.01₄₀₀; Pickering,⁶ 3.39₄₀₀; Berthelot,⁶⁹ 3.0; Agostini,² 2.07₅₀₀[?]. See also Lorenz and Hering,² Lorenz and Fox,¹ and Weber.¹

CdCl₂ (liq.). Weber¹ found $F = -10.5^{566}$.

CdCl₂ · H₂O (c). Pickering⁶ found $S = 0.62$. Thomsen¹⁵ reported $S = 0.76$ for a dihydrate, but undoubtedly his sample was the monohydrate.

CdCl₂ · 2½ H₂O (c). Cohen and Bruins³ found $S = -2.94_{400}$; Pickering⁶ reported $S = -2.29$ for a dihydrate, but his sample must have been largely the hydrate with 2½ H₂O. The former value yields, for CdCl₂ · 2½ H₂O (c), $Q_f = 269.93$. Electromotive force data on the cell reaction, Cd (c) + PbCl₂ (c) + 2½ H₂O (satd. soln.) = CdCl₂ · 2½ H₂O (c) + Pb (c), were obtained by Vosburg¹ and Taylor and Perrott.¹ The latter investigators also obtained data on the analogous cells with AgCl (c) and HgCl (c). These data yield, respectively, for CdCl₂ · 2½ H₂O (c), $Q_f = 270.02, 269.90, 269.42$, and 269.58. The values from the cell with lead chloride are probably the best. See also Getman.³

CdCl₂ · 4H₂O (c). Worobiew¹ reported $Q = -0.76$ for the heat of congruent melting of the tetrahydrate.

CdCl₂ · 2HCl · 7H₂O (c). Berthelot⁶⁹ measured the heat of solution.

CdCl₂ · CdO · H₂O (c). Tassilly¹ measured the heat of solution.

CdSO₄ (aq.). Thomsen¹⁵ found $Q = 5.74$ for the heat of the reaction of CdSO₄(200) with BaCl₂(200); whence, for CdSO₄(200), $Q_f = 232.70$. Holsboer¹ measured the heat of dilution of aqueous cadmium sulfate. See also von Steinwehr,¹ Ishikawa,² and Ishikawa and Murooka.¹

CdSO₄ (c). For the heat of solution, Thomsen¹⁵ found 10.74₄₀₀; Cohen, Helderman, and Moesveld,¹ 10.69₄₀₀.

CdSO₄ · H₂O (c). Thomsen¹⁵ measured the heat of solution.

CdSO₄ · 2½ H₂O (c). The data on the heat of solution are: Thomsen,¹⁵ 2.66₄₀₀; Cohen, Helderman, and Moesveld,¹ 2.54₄₀₀; Holsboer,¹ 2.67. See also Kohnstamm and Cohen¹ and Carpenter and Jette.¹

CdSO₄ · 2½ H₂O (c). Matignon¹⁸ measured the heat of solution.

CdS₂O₆ (aq.). Thomsen¹⁵ measured the heat of the reaction of BaS₂O₆(400) with CdSO₄(400) to be 5.60.

Cd⁺⁺ (aq.). Extrapolation to infinite dilution of the values for CdCl₂ (aq.) and for CdSO₄ (aq.) yield for, Cd⁺⁺(∞), $Q_f = 17.1$ and 17.6,

respectively. The latter value is probably the more accurate on account of the less uncertain extrapolation. See also Latimer.²

CdO (c). For the heat of combustion of cadmium to form CdO (c), Moose and Parr¹ found the value 65.2, Mixer¹⁵ found 64.2. Mixer's¹⁵ data on the reaction of Cd (c) with Na₂O₂ (c) yield, for CdO (c), $Q_f = 60$, but this value is not as accurate as the directly measured ones.

Cd₄O (c). Tanatar⁷ claimed to have formed this substance, and measured its heat of solution to be 16.9 and 13.9 in aqueous H₂SO₄ and aqueous HCl, respectively.

CdH (g). The values for the energies of dissociation and excitation of gaseous CdH are from the works of Bengtsson and Hulthen,¹ Svensson,² and Bengtsson and Rydberg.¹

Cd(OH)₂ (c). Thomsen¹⁵ measured the heats of the reactions, CdSO₄(400) + Ba(OH)₂(400) = Cd(OH)₂(c) + BaSO₄(c) and CdSO₄(400) + 2KOH(200) = Cd(OH)₂(c) + K₂SO₄(800), to be 13.07 and 7.07, respectively. From these data we have obtained, for Cd(OH)₂(c), $Q_f = 133.6$. For the reaction of CdCl₂(aq.) with 2KOH(aq.), Agostini² found $Q = 5.66$. From electromotive force data on the cell in which the reaction was presumably Cd(c) + HgO(c) + H₂O(liq.) = Hg(liq.) + Cd(OH)₂(c), Maier⁴ found $Q = 36.4$.

CdF₂ (aq.). Petersen³ measured the heat of the reaction of CdCl₂(aq.) with 2AgF(c) to be 31.9. Mulert¹ measured the heat of solution of CdO(c) in aqueous (20%) HF to be 23.45.

CdBr₂ (aq.). Thomsen¹⁵ measured the heats of reaction of BaBr₂(200) with CdSO₄(200) and with H₂SO₄(200) to be 6.88 and 9.54, respectively; whence, for CdBr₂(400), $Q_f = 76.17$. From direct measurement, Nernst⁶ obtained, for CdBr₂(aq.), $Q_f = 76.3$. Getman³ obtained electromotive force data on the cell in which the reaction was CdBr₂(aq., satd.) + Hg(liq.) = Cd(c) + Hg₂Br₂(c). He found $Q = 25.66$; whence, for CdBr₂(aq., satd.), $Q_f = 74.9$. See also Herschkowitsch.²

CdBr₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 0.44₄₀₀; Varet,² 0.4¹⁵.

CdBr₂ (liq.). Weber¹ found $F = -5.0^{580}$. See also Lorenz and Fox.¹

CdBr₂ · 4H₂O (c). Thomsen¹⁵ measured the heat of solution.

CdBr₂ · CdO · H₂O (c). Tassilly¹ measured the heat of solution in aqueous HBr.

CdBr (g). Sponer⁴ estimated $D^{\circ} = -60$. Wieland¹ reported the energy of excitation.

CdI₂ (aq.). Thomsen¹⁵ measured the heats of reaction of BaI₂(200) with CdSO₄(200) and with H₂SO₄(200) to be 9.61 and 9.55, respectively; whence, for CdI₂(400), $Q_f = 47.6$.

CdI₂ (c). Thomsen¹⁵ found $S = -0.96_{400}$. Taylor and Perrott¹ measured the heats of the reaction of 2KI(aq.) with Cd(c) + I₂(c) and with CdI₂(c), to be 52.37 and 3.93, respectively; whence, for CdI₂(c), $Q_f = 48.44$. The electromotive force data of Taylor and Perrott¹ yield, for CdI₂(c), $Q_f = 48.18$ and 48.97. Similar data by Vosburg¹ yield 48.37.

See also Yoshida,¹ Cohen, Hetterschij, and Moesveld,¹ Cohen and Bruins,^{1, 2, 4} and Wasastjerna.¹

CdI₂ (liq.). We have estimated the heat of fusion.

CdI₂ (g). Schmidt and Walter¹ calculated $V = -28.7^{700}$.

CdI₂ (CH₃OH). Timofejew² measured the heat of solution of cadmium iodide in methyl alcohol.

CdI₂ (C₂H₅OH). Timofejew² measured the heat of solution in ethyl alcohol.

CdI (g). Sponer⁴ estimated $D^{\circ} = -32$. Wieland¹ gave a value for the energy of excitation.

CdI₂ · CdO · H₂O (c). Tassilly¹ measured the heat of solution in aqueous HI.

CdS (c). Thomsen¹⁵ measured the heat of reaction of aqueous CdSO₄ with aqueous Na₂S, obtaining $Q = 27.12$; whence, for CdS (c), $Q_f = 34.6$. Mixer's¹⁵ data on the reaction of CdS (c) with Na₂O₂ (c) yield $Q_f = 35$. See also the equilibrium data of Jellinek and Podjaski¹ and Jellinek and Zucker.¹

CdSe (c). Fabre^{1, 2} measured the heats of the reactions, CdSe (c) + 4 Br₂ (liq.) + 4 H₂O (liq.) = (CdBr₂ + 6 HBr + H₂SeO₄) (aq.), CdSO₄ (500) + Na₂Se (500) = Na₂SO₄ (1000) + CdSe (c), and CdI₂ (500) + H₂Se (500) = CdSe (c) + 2 HI (500), to be 100.0, 41.2, and 27.1, respectively; whence, for CdSe (c), $Q_f = 17.0$, 27.1, and 34, respectively. We have taken 25 as a very rough average.

CdTe (c). Fabre's³ data on the reaction of CdTe (c) with bromine water yield $Q_f = 16$, but this value is probably not very accurate (see CdSe (c)).

CdN₆ (c). Wohler and Martin¹ measured the heat of decomposition into Cd (c) and 3 N₂ (g) to be 106.2.

Cd(NO₃)₂ (aq.). Thomsen¹⁵ measured the heat of the reaction of Ba(NO₃)₂ (200) with CdSO₄ (200) to be 5.13; whence, for Cd(NO₃)₂ (400), $Q_f = 115.67$.

Cd(NO₃)₂ (c). Malquori,¹ from equilibrium data, computed $Q = 55.9^{260}$ for the reaction, 2 Cd(NO₃)₂ (c) = CdO (c) + 4 NO₂ (g) + 2 O₂ (g); whence, for Cd(NO₃)₂ (c), $Q_f = 77.1$. But the result seems very much too low, as it would require the heat of solution to be 40.

Cd(NO₃)₂ (liq.). Reisenfeld and Milchsack¹ reported the heat of fusion.

Cd(NO₃)₂ · nH₂O (c). Thomsen¹⁵ measured the heats of solution of the mono- and tetrahydrates.

CdCl₂ · nNH₃ (c). Biltz, Klatte, and Rahlfs¹ and Biltz and Mau¹ obtained dissociation pressure data on the amines with 1, 2, 4, 6, and 10 NH₃; Ephraim^{1, 9} on the hexamine. Tassilly¹ found the heat of solution of the diammine in aqueous HCl to be 8.56.¹⁶

CdBr₂ · nNH₃ (c). Biltz and Mau¹ obtained dissociation pressure data on the amines with 1, 2, 6, and 12 NH₃; Ephraim^{1, 9} on the hexam-

mine. Tassilly¹ measured the heat of solution of the diammine in aqueous HBr to be 7.77.¹⁵

$\text{CdI}_2 \cdot n\text{NH}_3$ (c). Biltz and Mau¹ obtained dissociation pressure data on the amines with 2 and 6 NH_3 ; Ephraim^{1, 9} on the hexammine. Tassilly¹ found the heat of solution of the diammine in aqueous HI to be 11.9.¹⁵

$\text{CdCl}_2 \cdot 4 \text{NH}_4\text{Cl}$ (c). Tassilly¹ measured the heat of solution.

$\text{CdCl}_2 \cdot \text{NH}_4\text{Cl} \cdot \frac{1}{2} \text{H}_2\text{O}$ (c). Tassilly¹ measured the heat of solution.

$\text{CdBr}_2 \cdot \text{NH}_4\text{Br} \cdot \frac{1}{2} \text{H}_2\text{O}$ (c). Tassilly¹ measured the heat of solution.

$\text{CdI}_2 \cdot \text{NH}_4\text{I} \cdot \frac{1}{2} \text{H}_2\text{O}$ (c). Tassilly¹ measured the heat of solution.

$\text{CdSO}_4 \cdot n\text{NH}_3$ (c). Ephraim⁸ obtained dissociation pressure data on the amines with 1, 2, 5, and 6 NH_3 . See also Isambert³ and Ephraim.¹⁰

$\text{Cd}(\text{ClO}_3)_2 \cdot n\text{NH}_3$ (c). Ephraim and Jahnson¹ obtained dissociation pressure data on the amines with 4 and 6 NH_3 .

Cd_mSb_n (c). Biltz and Haase¹ computed the heats of formation of CdSb and Cd_3Sb_2 from the heats of solution in $(\text{KBr} + \text{Br}_2)$ (aq.) of Cd, Sb, and the solid alloys.

CdCO_3 (c). Thomsen¹⁵ measured the heat of reaction of CdSO_4 (400) with Na_2CO_3 (400) to be 0.36; whence, for CdCO_3 (c), $Q_f = 178.56$. The equilibrium data of Andrussow¹ and Jander¹ give -21.8 and -22.0 for the reaction, CdCO_3 (c) = CdO (c) + CO_2 (g), whence $Q_f = 181.4$.

$\text{Cd}(\text{CN})_2$ (c). Joannis¹ measured the heat of solution of $\text{Cd}(\text{CN})_2$ (c) in aqueous HCl to be 5.8,²¹ and in aqueous H_2SO_4 to be 8.3.²⁰

$\text{Cd}(\text{ONC})_2$ (c). Wohler and Martin¹ measured the heat of decomposition of cadmium fulminate into Cd (c) + 2 CO (g) + N_2 (g) to be 89.0.

$\text{Cd}(\text{CN})_2 \cdot \text{CdO} \cdot 5 \text{H}_2\text{O}$ (c). Joannis¹ measured the heat of solution in aqueous sulfuric acid.

2 $\text{CdI}_2 \cdot \text{PbI}_2$ (c). Mosnier¹ measured the heat of solution.

CdZn_n (c). Herschkowitsch² computed the heats of formation of the solid alloys, $\text{CdZn}_{0.36}$, $\text{CdZn}_{1.28}$, and $\text{CdZn}_{4.61}$, from data on the heats of solution in $(\text{KBr} + \text{Br}_2)$ (aq.).

CdPb_n (c). See Magnus and Mannheimer.¹

CdSn_n (c). See Magnus and Mannheimer.¹

MERCURY

Hg (liq.). Standard state.

Hg (g). The vapor pressure of mercury, whose vapor is practically monatomic, was studied by Stock and Zimmerman,¹ Hertz,¹ Thorpe,¹ Hagen,¹ Ruff and Bergdahl,¹ Regnault,⁵ Laby,¹ Morley,¹ Jewett,¹ Gebhardt,¹ Villiers,¹ van der Platts,¹ Menzies,^{2, 3a} Bernhart,¹ Haber and Kerschbaum,¹ Caillietet, Colardeau, and Riviere,¹ Poindexter,¹ Eger-ton^{1, 2, 3} Smith and Menzies,¹ Kahlbaum,¹ Heycock and Lamplough,¹ Hill,¹ Jenkins,³ Rodebush and Dixon,² Ramsay and Young,³ Callendar and Griffiths,¹ Pfaundler,¹ Scott,¹ Volmer and Eastman,¹ Volmer and Kirchoff,¹ and Young.¹ The vapor pressure data have been reviewed by Randall,² whose equation gives $V = -14.60$. The following are the directly measured values of the heat of vaporization of mercury at 623°:

Person,^{3, 4} -12.4; Kurbatoff,^{1, 1a} -13.6; Muscelleanii,¹ -12.77; Konowalow,² -15.5; Marignac,² -15.5. See also Beckmann and Liesche.¹

The energy states of gaseous monatomic mercury are evaluated from the data of Fowler³ and Paschen.⁹ See also Carroll¹ and Valasek.¹

Hg (c). The data on the heat of fusion of mercury are: Person,^{3, 4} -0.60; Koref,¹ -0.57; Bridgman,⁵ -0.54. See also Pollitzer,¹ Langlois,¹ Henning,³ and Wilhelm.^{1, 1a}

Hg₂ (g). Winans² reported $D^\circ = -1.4$.

HgI₂ (c, red). Varet¹ measured, at 12°, the heats of the reactions of Hg (liq.), HgI₂ (c), Hg₂I₂ (c), Hg₂Cl₂ (c), HgBr (c), Hg₂SO₄ (c), Hg₂(C₂H₃O₂)₂ (c), and Hg₂(NO₃)₂ (aq.), respectively, with KI (aq.) or KI₃ (aq.). His various data yield the following values for HgI₂ (c, red): $Q_f = 25.2, 25.3, 25.3, 25.3, 25.1, 25.4$, and 25.2.

HgI₂ (c, yellow). For the heat of transition of mercuric iodide from the red to the yellow form, Bridgman⁶ reported -0.547¹²⁶; Schwartz,¹ -0.522¹²⁷; Steiner and Johnston,¹ -0.64; Guinchaut,⁴ -0.68¹³⁰; Brockhorst,¹ -0.42 to -0.56. From the difference in the heats of solution, Berthelot⁸⁴ found $T = -3.0$.

HgI₂ (liq.). The data on the heat of fusion of HgI₂ (c, red) are: Guinchaut,⁴ -4.45²⁵⁰; Beckmann,² -5.5; Rinse,¹ -4.9.

HgI₂ (g). Vapor pressure data on mercuric iodide were reported by Rinse,¹ Stelzner and Niederschulte,¹ Arctowski,¹ Johnson,¹ Ditte,¹¹ Prideaux,¹ and Schmidt and Walter.¹ These data were reviewed by Egerton and Edmondson,¹ and their values give -19.6 for the heat of sublimation at 256° and -15.0 for the heat of vaporization.

Hg₂I₂ (c, yellow). Varet's data (see paragraph under HgI₂ (c, red)) yield, for this substance, $Q_f = 28.87$. The electromotive force data of Vosburgh² yield $Q_f = 28.42$ and 28.93.

HgI (g). Vapor pressure data on Hg₂I₂ were reported by Stelzner and Niederschulte,¹ whose data yield -6.4 to -5.8 for the heat of sublimation of 328 grams of mercurous iodide. According to the vapor density data, gaseous mercurous iodide is either HgI or Hg + HgI₂. The heat of sublimation data indicate that the vapor is HgI. Sponer⁴ estimated the energy of dissociation of HgI (g) to be about -19.

HgI₄ (aq.). Thomsen¹⁵ measured the heat of solution of HgI₂ (c) in 2 KI (200) to be 3.48.

HgBr₂ (c). By direct measurement, Nernst⁸ and Varet¹ obtained $Q_f = 40.5$ and 40.70, respectively. Varet's¹ data on the reaction with aqueous KI yield $Q_f = 40.70$.

HgBr₂ (liq.). Beckmann¹ reported $F = -4.5$.²³⁶

HgBr₂ (g). Vapor pressure data were reported by Stelzner and Niederschulte,¹ Johnson,¹ Prideaux,¹ Arctowski,¹ and Jung and Ziegler.¹ Their data (see Egerton and Edmondson¹) yield -19.1 for the heat of sublimation and -14.6 for the heat of vaporization.

HgBr (g). From spectroscopic data Jung and Ziegler¹ obtained values for the reaction, $\text{HgBr}_2 (\text{g}) = \text{Br} (\text{g}) + \text{HgBr} (\text{g})$, and for the energy

of excitation of HgBr (g) . The vapor pressure data of Jung and Ziegler¹ yield -19.6 for the heat of sublimation of 281 grams of mercurous bromide. These authors believed the vapor to be $\text{Hg} + \text{HgBr}_2$, but it is more likely HgBr . Sponer⁴ found from spectroscopic data a value for the energy of dissociation of HgBr (g) which yields, for this substance, $Q_f = -16$. Wieland¹ gave a value for the energy of excitation of HgBr (g) .

$\text{HgBr}_4^- \text{ (aq.)}$. Thomsen¹⁵ measured the heat of solution of $\text{HgBr}_2 \text{ (c)}$ in 2 KBr (200) to be 1.64; Berthelot⁸⁴ found 3.0^{11} in 2 HBr (aq.) .

$\text{HgBr}_2 \text{ (aq.)}$. By working with dilute solutions, Berthelot⁸⁴ determined the true heat of solution of $\text{HgBr}_2 \text{ (c)}$ to be -2.4 .

$\text{Hg}_2\text{Cl}_2 \text{ (c)}$. Gerke's¹ data on the cell in which the reaction was $2 \text{ Hg (liq.)} + \text{Cl}_2 \text{ (g)} = \text{Hg}_2\text{Cl}_2 \text{ (c)}$ yield $Q_f = 63.33$. See also the data of Lewis and Randall¹ on the cell in which the reaction was $\text{H}_2 \text{ (g)} + \frac{1}{2} \text{ Hg}_2\text{Cl}_2 \text{ (c)} = \text{HCl (555)} + \text{Hg (liq.)}$, Ellis¹ and Harned and Brumbaugh's¹ data on the same reaction, and Rossini.¹⁰ Varet's¹ data on the reactions of mercurous chloride with KI (aq.) , with $\text{KI}_3 \text{ (aq.)}$, and with $\text{KNO}_3 \text{ (aq.)}$, yield, for $\text{Hg}_2\text{Cl}_2 \text{ (c)}$, $Q_f = 62.65$, 62.65 , and 62.60 . Brodsky's¹ electromotive force data on the cell reaction, $\text{Hg}_2\text{Cl}_2 \text{ (c)} + 2 \text{ Br}^- \text{ (aq.)} = \text{Hg}_2\text{Br}_2 \text{ (c)} + 2 \text{ Cl}^- \text{ (aq.)}$, yield $Q_f = 62.78$.

HgCl (g) . The vapor pressure data of Maier,¹ Smith and Calvert,² von Richter,¹ and Stelzner and Niederschulte¹ yield -19.2 for the heat of sublimation, but the value is not accurate. In order to be in accord with the spectroscopic data, the vapor of mercurous chloride must be HgCl and not $2 \text{ Hg} + \text{Cl}_2$. Sponer⁴ found $D^\circ = -32$ for HgCl (g) from spectroscopic data; whence, for the latter, $Q_f = -12$. Wieland¹ gave a value for the energy of excitation of HgCl (g) .

$\text{HgCl}_2 \text{ (c)}$. Thomsen¹⁵ measured the heats of the reactions of 4 KCl (aq.) with $\text{Hg}_2\text{Cl}_2 \text{ (c)} + \text{Cl}_2 \text{ (g)}$, and with $\text{HgCl}_2 \text{ (c)}$. His data yield, for the latter, $Q_f = 53.4$. See also Andrews.¹⁶

$\text{HgCl}_2 \text{ (g)}$. The vapor pressure data of Richter,¹ Prideaux,¹ Johnson,¹ Stelzner and Niederschulte,¹ and Schmidt and Walker,¹ which show an abnormal trend, yield -14.6 for the heat of vaporization, and -18.7 for the heat of sublimation at the melting point. According to Wyneken¹ and Mitscherlich,¹ the vapor is little dissociated.

$\text{HgCl}_2 \text{ (liq.)}$. From the foregoing, we have calculated $F = -4.1$.²⁷⁷

$\text{HgCl}_2 \text{ (aq.)}$. Thomsen's¹⁵ data on the reaction between $\text{HgCl}_2 \text{ (aq.)}$ and 2 KI (aq.) yield, for the former, $Q_f = 50.8$. Varet's¹ data leads to the same value.

The data on the heat of solution of $\text{HgCl}_2 \text{ (c)}$ in water are: Thomsen,¹⁵ -3.32_{300} ; Berthelot,⁷ -3.1 ; Berthelot,¹⁹ -2.04 ; Pickering,⁸ -2.12_{300} . The value of Thomsen¹⁵ yields, for $\text{HgCl}_2 \text{ (aq.)}$, $Q_f = 50.1$.

$\text{HgO (c, yellow ppt.)}$. Thomsen¹⁵ measured the heats of reaction of 2 KOH (200) with $\text{HgCl}_2 \text{ (400)}$, $\text{K}_2\text{HgCl}_4 \text{ (400)}$, and $\text{K}_2\text{HgBr}_4 \text{ (400)}$, respectively, to be 8.10, 6.81, and -5.26 ; whence, for $\text{HgO (c, yellow ppt.)}$, $Q_f = 20.00$, 20.70 , and 20.84 . Berthelot⁵⁵ measured the heat of solution of

the yellow oxide in aqueous HCN to be 31.6, and in aqueous HCl to be 18.6; whence, for HgO (c, yellow), $Q_f = 21.0$.

HgO (c, red). Berthelot's⁵⁵ data yield $Q = 30.8$ for the heat of solution of HgO (c, red) in aqueous HBr to form the solid HgBr₂; whence, for HgO (c, red), $Q_f = 21.3$. Varet¹ found the same value for the heat of solution of red HgO as did Berthelot for the yellow form, and concluded that the heat of transformation was small; but such a method of comparison is inaccurate because it involves the assumption that the systematic errors in the work of the two experimenters were the same in value. The dissociation pressure data of Taylor and Hulett¹ yield, for HgO (c, red), $Q_f = 21.6$. The electromotive force data of Ishikawa and Kimura,¹ Fried,¹ and Brönsted⁵ on the cell reaction, HgO (c, red) + H₂ (g) = H₂O (liq.) + Hg (liq.), yield $Q = 46.77$, 46.88, and 46.65; whence, for HgO (c, red), $Q_f = 21.60$, 21.49 and 21.72, respectively. In differentiating between the red and yellow forms of mercuric oxide we imply not a difference in the crystalline species, but merely a difference in the heat contents, which may be due to the difference in the size of the crystals of the two forms.

Hg₂(NO₃)₂ (aq.). Thomsen¹⁵ measured the heats of the reactions of aqueous mercurous nitrate with KCl (aq.), KBr (aq.), and KI (aq.); and his data yield, for Hg₂(NO₃)₂ (aq.), $Q_f = 57.8$, 58.3, and 57.9. See also Berthelot⁸⁵ and Nernst.⁶

Hg₂(NO₃)₂ · 2 H₂O (c). Varet¹ measured the heat of solution of this substance in 2 HI (aq.) and in (3 HI + I₂) (aq.) to be 32.8 and 63.9, respectively; whence, for the solid dihydrate, $Q_f = 206.6$ and 206.4. Varet's¹ similar data on the solution of the dihydrate in aqueous KI, KBr, and KCl yield, for Hg₂(NO₃)₂ · 2 H₂O (c), the mean value of $Q_f = 207.9$.

HgF₂ · nNH₃ (c). Biltz and Rahlfs² measured the dissociation pressures of the amines with 2, 4, and 5 NH₃.

HgX₂ · nHgO (c). Andre^{1, 4} measured the heats of solution of HgCl₂ · HgO (c), HgCl₂ · 2 HgO (c), HgCl₂ · 3 HgO (c), HgCl₂ · 4 HgO (c), HgBr₂ · HgO (c), HgBr₂ · 2 HgO (c), HgBr₂ · 3 HgO (c), and HgBr₂ · 4 HgO (c).

HgS (c). Thomsen¹⁵ found $Q = 46.10$ for the reaction between Na₂S (200) and HgCl₂ (200); whence, for HgS (c, black), $Q_f = 7.20$. Berthelot¹⁴ found $Q = 29.6$ for the reaction of HgCl₂ (aq.) with H₂S (aq.); whence, for HgS (c, black), $Q_f = 10.7$. Varet's¹ data on the reaction between HgO (c) and H₂S (aq.) yield, for HgS (c, black), $Q_f = 10.9$. Varet¹ measured the heat of transformation, HgS (c, black) = HgS (c, red), to be 0.30. See also the equilibrium data of Pelabon,¹ Rinse,¹ and Jellinek and Zakowski.¹

Hg₂(NO₃)₂ · HNO₃ (aq.). Varet¹ measured the heat of solution of Hg₂(NO₃)₂ · 2 H₂O (c) in HNO₃ (aq.) to be -12.4.

Hg₂O (c). Thomsen¹⁵ measured the heat of the reaction of (Hg₂(NO₃)₂ + 1.079 HNO₃) (aq.) with 3.079 NaOH (aq.), and his data yield, for Hg₂O (c), $Q_f = 21.67$. Varet's¹ data on the reaction of mercurous

chloride with aqueous KOH yield, for Hg_2O (c), $Q_f=21.7$. Varet's¹ data on the heat of reaction of solid mercurous acetate with aqueous KOH yield, for Hg_2O (c), $Q_f=21.4$.

$\text{Hg}_2(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Varet¹ measured the heats of reaction of this substance with aqueous KI and aqueous KI_3 , his data yielding, for solid mercurous acetate, $Q_f=203.2$ and 203.3 .

HgH (g). The values for the energy of dissociation and of excitation of gaseous HgH are taken from Bengtsson and Hulthen¹ and Hori.³

Hg_2SO_4 (c). Varet's¹ data on the reaction with KI (aq.), KI_3 (aq.), and KOH (aq.) yield, for Hg_2SO_4 (c), $Q_f=176.37$, 176.47 , and 176.85 . The data of Henderson and Stegeman¹ on the cell reaction, $\text{Pb(c)} + \text{Hg}_2\text{SO}_4\text{(c)} = \text{PbSO}_4\text{(c)} + 2\text{Hg(lq.)}$, yield $Q=42.14$; whence, for Hg_2SO_4 (c), $Q_f=176.36$. See also Ishikawa.⁴

HgSO_4 (c). Varet¹ measured the heat of solution of this substance in 2HCl (aq.), and his data yield, for HgSO_4 (c), $Q_f=165.7$. Varet's¹ data on the reaction of mercuric sulfate with aqueous HCN yield, for HgSO_4 (c), $Q_f=166.7$. Berthelot's⁸³ data on the heats of mixing HgSO_4 with HCl (aq.), with NaCl (aq.), and with H_2SO_4 (aq.) yield, for HgSO_4 (c), $Q_f=166.6$.

$\text{HgSO}_4 \cdot 4\text{H}_2\text{SO}_4$ (aq.). Varet¹ measured the heat of solution of HgSO_4 (c) in $4\text{H}_2\text{SO}_4$ (100) to be 4.4 .

$(\text{HgO})_3\text{SO}_3$ (c). Varet¹ measured the heat of solution of this substance in 6HCl (aq.) and $25\text{H}_2\text{SO}_4$ (aq.) to be 43.4 and 9.1 , respectively.

HgSe (c). Fabre² found the heat of solution of mercuric selenide in bromine water to be 76.1 , and the heat of mixing HgCl_2 (500) with Na_2Se (500) to be 70.4 ; whence, for HgSe (c), $Q_f=3.5$ and 8.0 , respectively.

Hg_2N_6 (c). Berthelot and Vieille¹⁰ found the heat of decomposition of mercury azide to be 143.5 ; Wohler and Martin¹ found 100.0 .

$\text{Hg}(\text{NO}_3)_2$ (aq.). Thomsen's¹⁵ data on the reaction of HgO (c) with HNO_3 (aq.) yield, for $\text{Hg}(\text{NO}_3)_2$ (aq.), $Q_f=57.0$. Varet's¹ data on the heat of solution of the hemihydrate in aqueous HCl and in aqueous HNO_3 yield, for $\text{Hg}(\text{NO}_3)_2$ (aq.), $Q_f=56.2$.

$\text{Hg}(\text{NO}_3)_2 \cdot \frac{1}{2}\text{H}_2\text{O}$ (c). Varet¹ measured the heat of solution of the hemihydrate in HCl (aq.), in KCN (aq.), and in HNO_3 (aq.) to be 4.62 , 24.0 , and -1.4 , respectively.

$\text{Hg}(\text{NO}_3)_2 \cdot 2\text{HgO} \cdot \text{H}_2\text{O}$ (c). Varet¹ measured the heat of solution of this substance in HNO_3 (aq.) and in KCN (aq.) to be 3.8 and 77.6 , respectively.

$(\text{Hg}_2\text{N})_2\text{O}$ (c). We have here formally considered all the mercury nitrogen compounds derived from Millon's base, $\text{Hg}_2\text{NH}_5\text{O}_3$, to be derivatives of the oxide $(\text{Hg}_2\text{N})_2\text{O}$, where the group Hg_2N has an ordinary valence of plus one. The thermochemistry of these compounds has been studied by Gaudechon,¹ who measured the heats of solution of the derivatives and of HgO in aqueous KCN . For the oxide $(\text{Hg}_2\text{N})_2\text{O}$ (c), Gaudechon¹ measured the heat of solution in KCN (aq.) to be 151.0 , and

for HgO (c) in KCN (aq.) to be 154.6; whence, for $(\text{Hg}_2\text{N})_2\text{O}$ (c), $Qf = -77.0$.

$(\text{Hg}_2\text{N})_2\text{O}$ (aq.). Gaudechon¹ measured the heat of solution of the solid.

$\text{Hg}_2\text{NOH} \cdot n\text{H}_2\text{O}$ (c). Gaudechon^{1, 2} measured the heats of solution, in aqueous KCN , of Hg_2NOH (c) and of the hydrates with $1\frac{1}{2}$, 2, and 4 H_2O .

$\text{Hg}_2\text{NCl} \cdot n\text{H}_2\text{O}$ (c). Gaudechon^{1, 2} measured the heats of solution, in aqueous KCN , of the hemi- and monohydrates.

$\text{Hg}_2\text{NCl} \cdot n\text{NH}_4\text{Cl}$ (c). Gaudechon^{1, 2} measured the heat of solution, in aqueous KCN , of $\text{Hg}_2\text{NCl} \cdot \text{NH}_4\text{Cl}$ (c) and of $\text{Hg}_2\text{NCl} \cdot 3\text{NH}_4\text{Cl}$ (c).

$\text{Hg}_2\text{NCl} \cdot n\text{NH}_3$ (c). Gaudechon^{1, 2} measured the heats of solution of the ammines with $\frac{1}{2}$ and 1 NH_3 .

$\text{Hg}_2\text{NCl} \cdot \frac{1}{2}\text{HgCl}_2$ (c). Gaudechon¹ measured the heat of solution in aqueous KCN .

Hg_2NBr (c). Gaudechon¹ measured the heat of solution in aqueous KCN .

$\text{Hg}_2\text{NBr} \cdot n\text{HgBr}_2$ (c). Gaudechon¹ measured the heats of solution, in aqueous KCN , of these compounds with $n = \frac{1}{4}$, $\frac{1}{2}$, 1, and 3.

$\text{HgCl}_2 \cdot n\text{NH}_3$ (c). Biltz, Klatte, and Rahlfs¹ measured the heat of solution of mercuric chloride and of the diammine in aqueous HCl to be -1.5 and 34.5 , respectively. Biltz and Mau¹ measured the heat of solution of the diammine in water to be 10.2 . Biltz and Mau¹ obtained dissociation pressure data on the ammines with 8 and $8\frac{1}{2}$ NH_3 .

$\text{HgBr}_2 \cdot n\text{NH}_3$ (c). Biltz, Klatte, and Rahlfs¹ obtained dissociation pressure data on the octammine, and measured the heat of solution of the diammine in aqueous (20 per cent) KCN .

$\text{HgI}_2 \cdot n\text{NH}_3$ (c). Biltz, Klatte, and Rahlfs¹ measured the dissociation pressures of the di- and octammines, and measured the heat of solution of the diammine in aqueous (20 per cent) KCN . For the dissociation, $\text{HgI}_2 \cdot 2\text{NH}_3$ (c) = $\text{HgI} \cdot \frac{3}{2}\text{NH}_3$ (c) + $1\frac{1}{2}\text{NH}_3$ (g), the data of these authors give $Q = 1\frac{1}{4}(-13.1)$.

$\text{HgF}_2 \cdot n\text{NH}_3$ (c). Biltz and Rahlfs² measured the dissociation pressures of the di-, tetra-, and pentammines.

$\text{HgBr}_2 \cdot 2\text{NH}_4\text{Br}$ (aq.). Varet's⁶ data on the heat of mixing yield $Qf = 160.8$. We have computed, from the ions, $Qf = 162.3$.

$\text{Hg}_2\text{Cl}_2 \cdot 2\text{NH}_3$ (c). Bonnefoi¹ calculated the heat of dissociation from the data of Isambert.¹

$\text{Hg}_2\text{SO}_4 \cdot n\text{NH}_3$ (c). Ephraim⁸ measured the dissociation pressures of these ammines, but the data can not be used because of uncertainty as to the products of dissociation.

HgC_2O_4 (c). Berthelot⁹⁰ measured the heat of solution of mercuric oxalate in 4 HCl (100).

$\text{Hg}_2(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Varet¹ found the heat of solution of mercurous acetate in KI (aq.) and in KI_3 (aq.) to be 36.6 and 67.5 ; whence, for $\text{Hg}_2(\text{C}_2\text{H}_3\text{O}_2)_2$ (c), $Qf = 203.16$ and 203.36 , respectively.

$\text{Hg}(\text{C}_2\text{H}_3\text{O}_2)_2$ (aq.). Berthelot⁹⁰ measured the heat of reaction of aqueous mercuric acetate with HCl (aq.), with aqueous acetic acid, and with KOH (aq.), respectively.

$\text{Hg}(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Berthelot⁹⁰ measured the heat of solution.

$\text{HgCl}_2 \cdot \text{CH}_3\text{OH}$ (c). Lloyd, Brown, Bunnell, and Jones¹ measured the dissociation pressures.

$\text{Hg}(\text{CN})_2$ (aq.). Thomsen¹⁵ found the heats of the reaction of HgCl_2 (400) with 4 KCN (100), and of $\text{K}_2\text{Hg}(\text{CN})_4$ (aq.) with HgCl_2 (400), to be 45.6 and 22.0, respectively; whence, for $\text{Hg}(\text{CN})_2$ (aq.), $Q_f = -64.8$. Varet¹ measured the heat of solution of HgSO_4 (c) in 2 HCN (250) to be 28.33, and of HgO (c, red) in 2 HCN (aq.) to be 31.6. Berthelot⁸⁷ measured the heat of the latter reaction to be 31.0¹⁵.

$\text{Hg}(\text{CN})_2$ (c). Thomsen's¹⁵ data yield -2.97 for the heat of solution; Berthelot⁷ found -3.0 .

$\text{Hg}(\text{CN})_4^{--}$ (aq.). Berthelot⁸⁷ measured the heats of mixing $\text{Hg}(\text{CN})_2$ (aq.) with 2 KCN (aq.), and of $\text{K}_2\text{Hg}(\text{CN})_4$ (aq.) with 2 HCl (aq.).

$\text{Hg}(\text{CN})_2 \cdot n\text{HgO}$ (c). Joannis¹ measured the heats of solution, in aqueous HCl , of these compounds with $n = \frac{1}{2}$ and 1.

$\text{Hg}(\text{CN})_2 \cdot n\text{NH}_4\text{CN}$ (aq.). Varet¹ measured the heat of mixing $\text{Hg}(\text{CN})_2$ (aq.) with 1 and 2 moles of NH_4CN (aq.), respectively.

$\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{X}$ (aq.). Varet² measured the heat of mixing $\text{Hg}(\text{CN})_2$ (aq.) with NH_4Cl (aq.), NH_4Br (aq.), and NH_4I (aq.), respectively.

$\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{X} \cdot n\text{H}_2\text{O}$ (c). Varet² measured the heats of solution of $\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{Cl} \cdot \frac{3}{4}\text{H}_2\text{O}$ (c), of $\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{Br} \cdot \text{H}_2\text{O}$ (c), and of $\text{Hg}(\text{CN})_2 \cdot \text{NH}_4\text{I} \cdot \frac{1}{4}\text{H}_2\text{O}$ (c).

$\text{Hg}(\text{ONC})_2$ (c). Kast and Selle¹ measured the heat of decomposition of mercuric fulminate to be 117.7. See also Berthelot and Vieille.¹

$\text{Hg}(\text{CNS})_2$ (c). Joannis¹ measured the heat of reaction of HgCl_2 (aq.) with 2 KCNS (aq.) to be 14.6.

Hg_{100}Bi (liq.). Tammann and Ohler¹ determined the heat of formation of this amalgam.

Hg_nSn (liq.). The values for Hg_{50}Sn (liq.) and Hg_{100}Sn (liq.) are from van Heteren,¹ Richards and Wilson,¹ and Tammann and Ohler.¹

Hg_nPb (liq.). The values for these amalgams, with $n = 100, 260$, and 1000, are from Richards and Garrod-Thomas¹ and Tammann and Ohler.¹

HgPb_2 (c). The value for this amalgam is obtained from the data of Gerke,¹ Brönsted,^{1, 4} and Henderson and Stegeman.¹

Hg_5Tl_2 (c). The data of Biltz and Meyer² yield $Q_f = 2.5$ for this amalgam.

Hg_nTl (liq.). The values for the liquid thallium amalgams are from Richards and Daniels¹ and Richards and Smith.²

Hg_mIn_n . See Richards and Wilson.¹

Hg_mZn_n (liq.). The values for the liquid zinc amalgams are from Richards and Lewis,¹ Richards and Wilson,¹ Favre,^{1, 2} Taylor,³ and Pearce and Eversole.¹

Hg_mCd_n (c), Hg_mCd (liq.). The values for the liquid and solid cadmium amalgams are from Richards and Garrod-Thomas,¹ Biji,¹ Richards and Forbes,¹ Cohen,⁵ Carhart,¹ Richards and Lewis,^{1, 2} Richards, Frevert, and Teeter,¹ Hulett,¹ Tammann and Ohler,¹ Richards and Wilson,¹ Getman,¹ and Hildebrand, Foster, and Beebe.¹

HgBr₂ · nZnBr₂ (aq.). Varet^{2, 6} measured the heat of mixing HgBr₂ (aq.) with $\frac{1}{2}$, 1, and 2 moles of ZnBr₂ (aq.).

Hg(CN)₂ · ZnCl₂ (aq.). Varet^{2, 6} measured the heat of mixing.

Hg(CN)₂ · ZnCl₂ · 7 H₂O (c). Varet^{2, 6} measured the heat of solution.

Hg(CN)₂ · ZnBr₂ (aq.). Varet^{2, 6} measured the heat of mixing.

Hg(CN)₂ · ZnBr₂ · 8 H₂O (c). Varet^{2, 6} measured the heat of solution.

HgBr₂ · nCdBr₂ (aq.). Varet^{2, 6} measured the heat of mixing HgBr₂ (aq.) with $\frac{1}{2}$, 1, and 2 moles of CdBr₂ (aq.).

Hg(CN)₂ · nCdX₂ (aq.). Varet measured the heat of mixing Hg(CN)₂ (aq.) with 1 mole of CdCl₂ (aq.), with $\frac{1}{2}$ and 1 mole of CdBr₂ (aq.), and with $\frac{1}{2}$ mole of CdI₂ (aq.).

nHg(CN)₂ · CdX₂ · mH₂O (c). Varet^{2, 6} measured the heats of solution of Hg(CN)₂ · CdCl₂ · 2 H₂O (c), Hg(CN)₂ · CdBr₂ · 3 H₂O (c), and 2 Hg(CN)₂ · CdI₂ · 8 H₂O (c).

COPPER

Cu (c). Standard state.

Cu (liq.). Data on the heat of fusion of copper at its melting point, 1083°, were reported by the following: Umino,³ -3.21; Glaser,¹ -2.65; Richards,^{1a} -2.70; Wust, Meuthen, and Durrer¹ (recalculated by Randall, Nielsen, and West¹), -3.24. See also Honda and Ishigaki.¹ These data were reviewed by Randall, Nielsen, and West.¹

Cu (g). Vapor pressure data were reported by Fery,¹ Greenwood,^{3, 4, 5, 7} Harteck,¹ Jones, Langmuir, and Mackay,¹ Ruff and Bergdahl,¹ Ruff and Konschak,¹ and Ruff and Mugdan.¹ From these data Randall, Nielsen, and West¹ computed the heat of sublimation at 25° to be -90.4. This value is much higher than those calculated from the same data by van Laar,¹ van Liempt,¹ Sherman,¹ and us; and is not in agreement with the calculations of Langmuir and Mackay,¹ and the measurements of Rosenhain and Ewen.¹ The measurements of Jones, Langmuir, and Mackay¹ lead to the value -82.0. We have selected Sherman's¹ value of -81.2.

The energy states of gaseous monatomic copper have been evaluated from the following: Fowler,³ Shenstone,^{1a} Kichlu,¹ Bacher and Goudsmit,¹ Krueger,² Lang,^{1a} and Wahlin.²

Cu₂O (c). Maier's^{1a} equilibrium data on the reaction, Cu₂O (c) + H₂ (g) = 2 Cu (c) + H₂O (g), yield $Q=16.45$; whence, for Cu₂O (c), $Q_f=41.35$. Maier's⁴ electromotive force data on the cell reaction, Cu₂O (c) + H₂ (g) = 2 Cu (c) + H₂O (liq.), yield $Q=27.45$; whence, for Cu₂O (c), $Q_f=40.92$. From the data on entropies and free energies of the substances in the foregoing reaction, Millar⁵ computed, for Cu₂O (c), $Q_f=40.64$.

Thomsen¹⁵ found $Q = 15.16$ for the reaction, $\text{Cu}_2\text{O} (\text{c}) + \text{H}_2\text{SO}_4 (100) = \text{Cu} (\text{c}) + \text{CuSO}_4 (100) + \text{H}_2\text{O} (\text{liq.})$; whence, for $\text{Cu}_2\text{O} (\text{c})$, $Q_f = 42.5$. See also Wohler and Balz,² Allmand,^{1, 1a} Ishikawa and Kimura,¹ Nielsen and Brown,¹ Andrews,¹⁴ and Dulong.²

$\text{Cu}_2\text{O} (\text{liq.})$. Randall, Nielsen, and West¹ calculated the heat of fusion of cuprous oxide.

$\text{CuO} (\text{c})$. The data of von Wartenberg and Werth¹ yield for the reaction, $\text{CuO} (\text{c}) + \text{H}_2 (\text{g}) = \text{Cu} (\text{c}) + \text{H}_2\text{O} (\text{liq.})$, $Q = 38.3$; whence, for $\text{CuO} (\text{c})$, $Q_f = 38.5$. The values reported by Andrews¹⁴ and Dulong² nearly 100 years ago were 38.4 and 39.4, respectively. Randall, Nielsen, and West¹ reviewed the equilibrium data of Smyth and Roberts,¹ Roberts and Smyth,¹ Foote and Smith,¹ Wohler and Foss,¹ Wohler and Balz,² Moles and Paya,¹ and Ruer and Nakamota,¹ and concluded that, for $\text{CuO} (\text{c})$, $Q_f = 34.4$. Maier's⁴ electromotive force data on the cell reaction, $\text{Cu}_2\text{O} (\text{c}) + \text{H}_2\text{O} (\text{liq.}) = 2 \text{CuO} (\text{c}) + \text{H}_2 (\text{g})$, yield $Q = -30.0$; whence, for $\text{CuO} (\text{c})$, $Q_f = 38.4$. See also Biltz,⁸ Smyth and Roberts,¹ Brody and Mullner,¹ Halla,¹ Treadwell,¹ and Bernoulli.¹

$\text{CuO} (\text{liq.})$. From the foregoing data on equilibria involving both solid and liquid CuO , we have computed the heat of fusion to be -13.3^{13b} .

$\text{CuSO}_4 (\text{aq.})$. Thomsen's¹⁵ data on the heat of solution of CuO in aqueous H_2SO_4 yield, for $\text{CuSO}_4 (400)$, $Q_f = 200.8$. For the heat of the reaction, $\text{CuSO}_4 (400) + \text{Fe} (\text{c}) = \text{FeSO}_4 (400) + \text{Cu} (\text{c})$, Thomsen¹⁵ found $Q = 37.24$; whence, for $\text{CuSO}_4 (400)$, $Q_f = 198.7$. Data on the heat of dilution were reported by Thomsen,¹⁵ Perreu,² and Arrhenius.²

$\text{CuSO}_4 (\text{c})$. The data on the heat of solution are: Thomsen,¹⁵ 15.80_{800} ; Donnan and Hope,¹ 15.7 ; Pickering,⁷ 15.92_{400} ; Schottky,¹ 15.93_{400} .

$\text{CuSO}_4 \cdot \text{H}_2\text{O} (\text{c})$. The data on the heat of solution are: Thomsen,¹⁵ 9.32_{400} ; Donnan and Hope,¹ 10.1 ; Jorissen² (see Thomsen¹⁵), 9.33 ; Pickering,⁷ 8.90_{400} ; Schottky,¹ 9.33_{400} . See also Siggel.¹ Vapor pressure data on the system $\text{CuSO}_4 \cdot \text{H}_2\text{O} (\text{c}) - \text{CuSO}_4 (\text{c}) - \text{H}_2\text{O} (\text{g})$ were reported by Lescoeur,⁴ Siggel,¹ Schottky,¹ and Foote and Scholes.¹

$\text{CuSO}_4 \cdot 3 \text{H}_2\text{O} (\text{c})$. The data on the heat of solution are: Thomsen,¹⁵ 2.84_{400} ; Jorissen² (see Thomsen¹⁵), 3.08 ; Partington and Huntingford,¹ 3.46 ; Donnan and Hope,¹ 3.20 . Vapor pressure data on the system $\text{CuSO}_4 \cdot 3 \text{H}_2\text{O} (\text{c}) - \text{CuSO}_4 \cdot \text{H}_2\text{O} (\text{c}) - \text{H}_2\text{O} (\text{g})$ were reported by Lescoeur,⁴ Frowein,¹ and Carpenter and Jette.¹ These data were reviewed by Randall, Nielsen, and West.¹

$\text{CuSO}_4 \cdot 5 \text{H}_2\text{O} (\text{c})$. The data on the heat of solution are: Donnan and Hope,¹ -3.3 ; Favre,⁸ -3.17^{19} ; Pickering,⁷ -2.80_{800} ; Scholz,¹ -3.4_{400}^0 . See also Favre and Valson¹ and Perreu.¹ Vapor pressure data on the system $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O} (\text{c}) - \text{CuSO}_4 \cdot 3 \text{H}_2\text{O} (\text{c}) - \text{H}_2\text{O} (\text{g})$ were reported by Lescoeur,⁴ Carpenter and Jette,¹ Frowein,¹ Hollman,¹ Wilson,² Noyes and Westbrook,¹ Foote and Scholes,¹ Linebarger,¹ Partington,¹ Partington and Huntingford,¹ and Schumb.¹ These data were reviewed by Randall, Nielsen, and West.¹ The electromotive force data of Oholm¹ and Obata¹

on the cell reaction, $\text{Cu (c)} + \text{Hg}_2\text{SO}_4 \text{ (c)} + 5 \text{H}_2\text{O (satd. soln. of CuSO}_4\text{)} = \text{CuSO}_4 \cdot 5 \text{H}_2\text{O (c)} + \text{Hg (liq.)}$, yield $Q = 24.86$ and 24.71 , respectively. The average yields, for $\text{CuSO}_4 \cdot 5 \text{H}_2\text{O (c)}$, $Q_f = 545.34$. See also Cohen, Chattaway, and Tombrock,¹ Nielsen and Brown,¹ Bedeau,¹ and Burian.¹

CuCl (c). Thomsen¹⁵ measured the heat of reaction of cuprous-oxide with 2HCl (aq.) to be 14.66 ; whence, for CuCl (c) , $Q_f = 33.8$. Noyes and Chow¹ found $Q = 9.81$ for the reaction, $3 \text{CuCl (c)} + 1\frac{1}{2} \text{Sn (c)} = 1\frac{1}{2} \text{SnCl}_2 \text{ (aq.)} + 3 \text{Cu (c)}$; whence, for CuCl (c) , $Q_f = 37.15$. The electromotive force data of Noyes and Chow¹ on the cell reaction, $1\frac{1}{2} \text{H}_2 \text{ (g)} + 3 \text{CuCl (c)} = 3 \text{Cu (c)} + 3 \text{HCl (aq.)}$, yield $Q = 21.57$; whence, for CuCl (c) , $Q_f = 32.3$. From equilibrium data on the reaction between cuprous chloride and hydrogen, Watanabe^{1a, 2} calculated, for CuCl (c) , $Q_f = 32.6$. Bodlander and Storbeck¹ estimated $Q_f = 32.9$. See also Parravano and Malquorri.³ Thomsen's¹⁵ data on the reaction of cuprous chloride with $\text{KMnO}_4 \text{ (aq.)}$ yield, for CuCl (c) , $Q_f = 34.2$. Berthelot's⁵⁹ data on the reaction of cuprous chloride with hydrogen peroxide yield, for CuCl (c) , $Q_f = 37.1$. The data of Edgar and Cannon¹ on the equilibrium, $\text{CuCl (c)} + \text{AgCl (c)} = \text{CuCl}_2 \text{ (aq.)} + \text{Ag (c)}$, yield, for CuCl (c) , $Q_f = 32.0$. Sievert and Gotta's¹ data on the reaction, $\text{Cu (c)} + \text{CuCl}_2 \text{ (aq.)} = 2 \text{CuCl (c)}$, yield $Q = 3.80$; whence, for CuCl (c) , $Q_f = 33.9$.

CuCl (aq. HCl). Noyes and Chow¹ found the heat of solution of CuCl in HCl(500) to be -6.44 ; Berthelot⁵⁹ found values ranging from -0.8^{14} for HCl(5) to 9.5^{14} for HCl(60) .

Cu₂Cl₂ (liq.). Watanabe^{1a, 2} reported $F = -7.74^{430}$.

Cu₂Cl₂ (g). The vapor pressure data of von Wartenberg and Bosse¹ yield -19.2 for the heat of vaporization. The vapor of cuprous chloride is Cu_2Cl_2 .

CuCl₂ (aq.). Thomsen's¹⁵ data on the reactions, $\text{CuCl}_2(200) + \text{H}_2\text{SO}_4(200) = \text{CuSO}_4(200) + 2 \text{HCl}(200)$ and $\text{CuSO}_4(400) + \text{BaCl}_2(400) = \text{CuCl}_2(800) + \text{BaSO}_4 \text{ (c)}$, yield, for $\text{CuCl}_2(200)$, $Q_f = 64.0$. Data on the heat of dilution of aqueous cupric chloride were reported by Thomsen,¹⁵ Reicher and van Deventer,² Berthelot,⁵ and Partington and Soper.¹

CuCl₂ (c). The data on the heat of solution are: Favre and Silbermann,³ 9.9 ; Sabatier,² 11.2_{400}^{20} ; Partington and Soper,¹ 16.30_{200}^{25} ; Agostini,¹ 11.08_{600} ; Thomsen,¹⁵ 11.12_{600} .

CuCl₂ · 2 H₂O (c). The data on the heat of solution are: van Deventer and van der Stadt,¹ 3.71_{200} ; Thomsen,¹⁵ 4.21_{400} ; Biltz, Broham, and Wein,¹ 6.3 , in HCl(20) .

CuCl₂ · 3 CuO · nH₂O (c). Berthelot⁷⁷ measured the heats of solution in aqueous HCl of the anhydrous salt and the tetrahydrate.

CuO · CuCl₂ (c). Korveze,¹ from equilibrium data, reported $Q = 29.05$ for the reaction, $2 \text{CuCl}_2 \text{ (c)} + \frac{1}{2} \text{O}_2 \text{ (g)} = \text{Cl}_2 \text{ (g)} + \text{CuO} \cdot \text{CuCl}_2 \text{ (c)}$.

CuCl₂(C₂H₅OH). Partington and Soper¹ measured the heat of solution of cupric chloride in various amounts of ethyl alcohol.

CuH (g). The energy of dissociation and of excitation of gaseous CuH are taken from the work of Bengtsson and Hulthen.¹

Cu(OH)₂ (c). Sabatier⁹ and de Forcrand⁶³ measured the heats of solution of both the blue and the green forms of solid cupric hydroxide in aqueous nitric acid. Thomsen¹⁵ measured the heat of reaction of KOH (aq.) with CuSO₄ (aq.), and of Ba(OH)₂ (aq.) with CuSO₄ (aq.). See also Bouzat.¹

3 CuO · H₂O (c). Sabatier⁹ and de Forcrand⁶³ measured the heat of solution in aqueous nitric acid.

CuF₂ (aq.). Petersen³ measured the heat of reaction of CuCl₂(300) with 2 AgF to be 31.88.

Cu(ClO₃)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of CuSO₄ (200) with Ba(ClO₃)₂(200) to be 4.37.

Cu(ClO₄)₂ (aq.). The value for this substance has been computed from those for the ions.

CuClO₄ (aq.). Heinerth¹ reported $Q = -18.80$ for the reaction, Cu (c) + Cu(ClO₄)₂ (aq.) = 2 CuClO₄ (aq.).

CuBr (c). Thomsen¹⁵ measured the heat of reaction of Cu₂O (c) with 2 HBr (aq.) to be 20.76; whence, for CuBr (c), $Q_f = 26.0$. Bodlander and Storbeck¹ estimated $Q_f = 25.0$. Klein's¹ electromotive force data on the cell reaction, CuBr (c) + KI (aq.) = CuI (c) + KBr (aq.), yield, for CuBr (c), $Q_f = 26.6$.

Cu₂Br₂ (g). The vapor pressure data of von Wartenberg and Bosse¹ and of Jellinek and Rudat² yield -18.8 for the heat of vaporization at 1000°.

CuBr₂ (aq.). Rolla¹ measured the heat of solution of copper in bromine water to be 38.3.

CuBr₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 8.25₄₀₀²⁰; Sabatier,⁷ 7.9¹².

CuBr₂ · 4 H₂O (c). Sabatier⁷ measured the heat of solution.

CuBr₂ · 3 Cu(OH)₂ (c). Sabatier⁹ measured the heat of solution in aqueous HBr.

CuI (c). Thomsen¹⁵ measured the heat of reaction of Cu₂O (c) with 2 HI (aq.) to be 33.73; whence, for CuI (c), $Q_f = 17.2$. Bodlander and Storbeck¹ estimated $Q_f = 16.3$. Thomsen's¹⁵ data on the reaction, 2 CuSO₄ (aq.) + H₂O (liq.) + 2 KI (aq.) + H₂SO₃ (aq.) = 2 CuI (c) + (2 KHSO₄ + H₂SO₄) (aq.), yield, for CuI (c), $Q_f = 17.7$. Berthelot's⁵⁹ data on the reaction of aqueous cupric sulfate with aqueous KI yield, for CuI (c), $Q_f = 18.1$. Joannis⁷⁵ data on the reaction of cupric oxide with aqueous HI yield, for CuI (c), $Q_f = 16.2$.

CuI (g). From spectroscopic data, Butkow and Terenin¹ reported $Q = -131$ for the reaction CuI (g) = Cu* (g) + I (g).

Cu₂I₂ (g). The vapor pressure data of von Wartenberg and Bosse¹ yield -18.9 for the heat of vaporization at 1300°. Gaseous cuprous iodide is practically all Cu₂I₂.

CuI₂ (aq.). The value for aqueous cupric iodide is obtained from the ions.

CuI₂ (c). We have estimated the heat of formation of this substance.

CuS (c). By direct measurement, von Wartenberg¹⁰ found, for CuS (c), $Q_f = 11.61$. Berthelot¹⁴ found the heat of reaction of CuSO_4 (aq.) with H_2S (aq.) and with Na_2S (aq.) to be 13.2 and 37.4, respectively; whence, for CuS (c), $Q_f = 11.86$ and 12.3. For the reaction, $\text{CuSO}_4(200) + \text{Na}_2\text{S}(200) = \text{CuS (c)} + \text{Na}_2\text{SO}_4(400)$, Thomsen¹⁵ found $Q = 37.23$; whence, for CuS (c), $Q_f = 12.17$. Equilibrium data were reported by Biltz and Juza,¹ Preuner and Brockmoller,¹ Allen and Lombard,¹ and Halferdahl.¹

Cu_2S (c). By direct measurement, von Wartenberg¹⁰ found, for Cu_2S (c, III), $Q_f = 18.97$. Thomsen's data on the reaction of cuprous chloride with aqueous sodium sulfide yield, for Cu_2S (c, III), $Q_f = 20.1$. Equilibrium data involving cuprous sulfide were reported by Jellinek and Zakowski,¹ Allen and Lombard,¹ Biltz and Juza,¹ Preuner and Brockmoller,¹ Tubandt and Reinhold,¹ Halferdahl,¹ Stubbs,¹ Wajuchnowa,¹ Reinders and Goudriaan,¹ and Schenck and Hempelmann.¹ Data on the heats of transition of cuprous sulfide were obtained by Bellati and Lussana¹ and Bornemann and Hengstenberg.¹ These data were reviewed by Randall, Nielsen, and West,¹ whose values we have selected.

$3\text{CuO} \cdot \text{CuSO}_4$ (c). From their equilibrium data, Reinders and Goudriaan¹ assumed the existence of this substance, and reported $Q = 39.1$ for the reaction, 2CuSO_4 (c) + Cu_2O (c) = $3\text{CuO} \cdot \text{CuSO}_4$ (c) + SO_2 (g); but these data are uncertain.

$3\text{CuO} \cdot \text{CuSO}_4 \cdot 4\text{H}_2\text{O}$ (c). Sabatier⁹ measured the heat of solution of this substance in aqueous sulfuric acid.

Cu_2SO_4 (c). Recoura⁴ found $Q = 21.0$ for the reaction, Cu_2SO (c) = Cu (c) + CuSO_4 (aq.).

Cu_2SO_4 (aq.). From equilibrium data, Heinerth¹ computed $Q = -9.4$ for the reaction, CuSO_4 (aq.) + Cu (c) = Cu_2SO_4 (aq.).

CuS_2O_6 (aq.). The value for this substance is obtained from those for the ions.

$\text{CuS}_2\text{O}_6 \cdot 5\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{CuSO}_4 \cdot 2\text{HCl}$ (c). Ephraim⁷ obtained dissociation pressure data on this substance.

CuSe (c). Favre's² data on the reaction of aqueous cupric acetate with gaseous hydrogen selenide yield, for CuSe (c), $Q_f = 19$.

Cu_2Se (c). Favre's² data on the reaction of cuprous selenide with bromine water yield, for Cu_2Se (c, II), $Q_f = 14.5$. The equilibrium data of Tubandt and Reinhold¹ on the reaction, Ag_2S (c) + Cu_2Se (c) = Ag_2Se (c) + Cu_2S (c), yield, for Cu_2Se (c, I), $Q_f = 10.6$. Bellati and Lussana¹ gave $T = -1.12^{110}$ for the transition from II to I.

CuSeO_4 (aq.). Metzner¹ found $Q = 13.07$ for the reaction, CuSeO_4 (aq.) + 2KOH (aq.) = K_2SeO_4 (aq.) + Cu(OH)_2 (c).

$\text{CuSeO}_4 \cdot 5\text{H}_2\text{O}$ (c). Metzner¹ measured the heat of solution of the pentahydrate.

CuN_3 (c). Wohler and Martin¹ measured the heat of decomposition of copper azide to be 56.8.

$\text{Cu}(\text{NO}_3)_2$ (aq.). Thomsen¹⁵ measured the heat of the reaction, $2 \text{AgNO}_3(400) + \text{Cu}(c) = 2 \text{Ag}(c) + \text{Cu}(\text{NO}_3)_2(800)$, to be 35.63; whence, for $\text{Cu}(\text{NO}_3)_2(800)$, $Q_f = 83.55$. Thomsen's¹⁵ data on the reaction between aqueous barium nitrate and aqueous cupric sulfate yield, for $\text{Cu}(\text{NO}_3)_2(200)$, $Q_f = 81.4$. Data on the heat of dilution of aqueous copper nitrate were reported by Thomsen¹⁵ and Berthelot.⁵

$\text{Cu}(\text{NO}_3)_2$ (c). Guntz and Martin¹ measured the heat of solution.

$\text{Cu}(\text{NO}_3)_2 \cdot 3 \text{H}_2\text{O}$ (c). Sabatier⁹ measured the heat of solution.

$\text{Cu}(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ (c). The data on the heat of solution are: Sabatier,⁹ -10.5^{15} ; Thomsen,¹⁵ -10.71_{400} . Reisenfeld and Milchsack¹ found the heat of fusion to be -8.68^{26} .

$\text{Cu}(\text{NO}_3)_2 \cdot n\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetra- and hexammines.

$\text{Cu}(\text{NO}_3)_2 \cdot 3 \text{CuO} \cdot 3 \text{H}_2\text{O}$ (c). Sabatier⁹ measured the heat of solution in aqueous nitric acid.

$\text{CuCl}_2 \cdot n\text{NH}_3$ (aq.). Bouzat¹ measured the heat of adding 4, 6, 8, and 12 NH_3 (aq.) to CuCl_2 (aq.).

$\text{CuSO}_4 \cdot n\text{NH}_3$ (aq.). Bouzat¹ measured the heats of adding 4, 6, 8, and 12 NH_3 (aq.) to CuSO_4 (aq.).

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot n\text{NH}_3$ (aq.). Bouzat¹ measured the heats of adding 4, 6, 8, and 12 NH_3 (aq.) to 1 mole of aqueous cupric acetate.

$\text{Cu}(\text{NH}_3)_n^{++}$ (aq.). The values given for the heats of formation of these ions, with $n=4, 6, 8$, and 12, are purely formal, since the actual ion is probably $\text{Cu}(\text{NH}_3)_4^{++}$. The values are obtained from the values for the aqueous ammonia solutions of cupric acetate, cupric chloride, and cupric sulfate.

$\text{CuCl}_2 \cdot 2 \text{NH}_3$ (c). Bouzat¹ measured the heat of solution of the diammine to be 3.37 in 6 NH_3 (aq.) and 7.95 in HCl (aq.); Biltz, Brohan, and Wein¹ found the heat of solution in $\text{HCl}(20)$ to be 6.1 . Biltz, Klatte, and Rahlfs¹ reported $D = -21$.

$\text{CuCl}_2 \cdot 2 \text{NH}_3 \cdot \frac{1}{2} \text{H}_2\text{O}$ (c). Bouzat¹ measured the heat of solution in aqueous ammonia.

$\text{CuCl}_2 \cdot 3\frac{1}{2} \text{NH}_3$ (c). Biltz, Klatte, and Rahlfs¹ reported $D = -14.1$.

$\text{CuCl}_2 \cdot 4 \text{NH}_3 \cdot 2 \text{H}_2\text{O}$ (c). Bouzat¹ measured the heat of solution in aqueous ammonia.

$\text{CuCl}_2 \cdot n\text{NH}_3$ (c). Biltz, Klatte, and Rahlfs¹ reported dissociation pressure data on the amines with 5, 6, and 10 NH_3 . See also Biltz, Brohan, and Wein¹ and Ephraim.^{1, 3, 5}

$\text{CuCl}_2 \cdot 5 \text{NH}_3 \cdot n\text{H}_2\text{O}$ (c). Bouzat¹ measured the heats of solution of these hydrated pentammines with $\frac{1}{2}$ and $1\frac{1}{2}$ H_2O .

$\text{CuCl}_2 \cdot 2 \text{NH}_4\text{Cl} \cdot n\text{H}_2\text{O}$ (c). Bouzat¹ and Bouzat and Chauvenet¹ measured the heats of solution of the anhydrous compound and of the dihydrate.

$\text{CuCl} \cdot n\text{NH}_3$ (c). Biltz and Stollenwerk² obtained dissociation pressure data on the amines with 1, $1\frac{1}{2}$, and 3 NH_3 . See also Lloyd.¹

$\text{CuBr}_2 \cdot n\text{NH}_3$ (c). Biltz, Brohan, and Wein¹ measured the heat of

solution of the diammine in aqueous HCl, and obtained dissociation pressure data on the ammines with 2, $3\frac{1}{2}$, 5, 6, and 10 NH_3 . See also Biltz, Klatté, and Rahlfs¹ and Ephraim.^{1, 9}

$\text{CuBr} \cdot n\text{NH}_3$ (c). Biltz and Stollenwerk¹ obtained dissociation pressure data on the ammines with 1, $1\frac{1}{2}$, and 3 NH_3 . See also Lloyd.¹

$\text{CuI}_2 \cdot n\text{NH}_3$ (c). Biltz, Brohan, and Wein¹ reported dissociation pressure data on the ammines with 2, $3\frac{1}{2}$, 5, and 10 NH_3 . See also Ephraim.⁹

$\text{CuI} \cdot n\text{NH}_3$ (c). Biltz and Stollenwerk¹ measured the dissociation pressures of the ammines with $\frac{1}{2}$, 1, 2, and 3 NH_3 . See also Lloyd.¹

$\text{Cu}(\text{ClO}_3)_2 \cdot n\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetra- and hexammines.

$\text{Cu}(\text{IO}_3)_2 \cdot 5\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressure of the pentammine.

$\text{Cu}(\text{ClO}_4)_2 \cdot n\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetra- and hexammines.

$\text{CuSO}_4 \cdot n\text{NH}_3$ (c). Bouzat¹ measured the heats of solution in aqueous ammonia of the mono-, di-, and tetrammines. Ephraim^{8, 10} measured the dissociation pressures of the tetra- and pentammines. Bouzat¹ obtained data on the hexammine.

$\text{CuSO}_4 \cdot 4\text{NH}_3 \cdot 1\frac{1}{2}\text{H}_2\text{O}$ (c). Bouzat¹ measured the heat of solution in aqueous ammonia.

$\text{CuSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot n\text{H}_2\text{O}$ (c). Bouzat¹ measured the heat of solution of the hexahydrate; Favre³ (See Bouzat¹) measured that of the anhydrous salt. Caven and Ferguson¹ measured the dissociation pressures for the system, hexahydrate -dihydrate -water vapor, and found $D = -18.5$.

$\text{CuS}_2\text{O}_6 \cdot n\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetra- and pentammines.

$\text{CuS}_4\text{O}_6 \cdot 4\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures.

CuP_2 (c). Granger¹ obtained equilibrium data on the reaction, 2CuP_2 (c) = 2Cu (c) + P_4 (g).

Cu_3Sb (c). Biltz and Haase¹ measured the heats of solution in aqueous (30 per cent) KBr_3 of 3Cu (c) + Sb (c) and of Cu_3Sb (c).

$\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ (c). Berthelot¹² found the reaction of aqueous copper sulfate with aqueous sodium carbonate to go in two stages, with $Q = -2.1$ and 1.7 , respectively. The product is indefinite, but probably approximates $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ (c).

$\text{Cu}(\text{CHO}_2)_2$ (aq.). Berthelot^{9, 10} measured the heat of neutralization of aqueous formic acid with cupric hydroxide.

$\text{Cu}(\text{CHO}_2)_2$ (c). Berthelot^{9, 10} measured the heat of solution of cupric formate.

$\text{Cu}(\text{CHO}_2)_2 \cdot 4\text{H}_2\text{O}$ (c). Berthelot^{9, 10} measured the heat of solution of cupric formate tetrahydrate.

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$ (aq.). Berthelot^{5, 9} measured the heat of neutralization

of aqueous acetic acid with cupric hydroxide. Thomsen¹⁵ measured the heat of reaction of aqueous cupric acetate with aqueous barium hydroxide.

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Berthelot^{5, 9} measured the heat of solution of cupric acetate.

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{H}_2\text{O}$ (c). For the heat of solution, Berthelot^{5, 9} found -0.80_{220}^{10} ; Thomsen¹⁵ found 0.17_{400}^{18} .

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_3)_2$ (c). de Forcrand³ measured the heat of reaction of solid copper glycollate with aqueous hydrogen sulfide.

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_3)_2$ (aq.). de Forcrand³ measured the heat of reaction of aqueous cupric sulfate with aqueous lead glycollate.

$\text{Cu}_2\text{Cl}_2 \cdot \text{CO} \cdot 2 \text{H}_2\text{O}$ (aq.). Hammerl¹ reported the heat of formation of this substance.

$\text{Cu}_2\text{Cl}_2 \cdot \text{CO} \cdot 2 \text{H}_2\text{O}$ (c). Hammerl¹ reported the heat of formation of this substance.

$\text{CuCl}_2 \cdot 2 \text{CH}_3\text{OH}$ (c). Dissociation pressure data were reported by Lloyd, Brown, Bonnell, and Jones.¹

$\text{Cu}(\text{C}_2\text{H}_5\text{SO}_4)_2$ (aq.). Thomsen¹⁵ measured the heat of mixing aqueous barium ethyl sulfate with aqueous cupric sulfate.

CuONC (c). Wohler and Martin¹ measured the heat of decomposition to be 50.0.

CuCN (aq.). Varet³ measured the heat of reaction of cuprous iodide with aqueous mercuric cyanide.

Cu_3Sn (c). Biltz⁶ and Herschkowitsch² measured the heats of solution of various bronzes. Biltz⁶ found, for Cu_3Sn (c), $Q_f = 8.0$

Cu_2Zn_3 (c). Biltz,⁶ Baker,² Galt,¹ and Herschkowitsch² investigated the heats of formation of the brasses. Biltz⁶ found, for Cu_2Zn_3 (c), $Q_f = 16.0$.

Cu_2Cd_3 (c). This alloy was studied by Biltz and Haase,¹ Roos,² and Schreiner and Seljesaeter.¹ Biltz and Haase¹ found, for Cu_2Cd_3 (c), $Q_f = 3.0$.

$\text{CuC}_2\text{O}_4 \cdot 5 \text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the pentammine of cupric oxalate.

$\text{Cu}(\text{CHO}_2)_2 \cdot 4 \text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetrammine of cupric formate.

$\text{Cu}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 4 \text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetrammine of cupric acetate.

$\text{Cu}(\text{CNS})_2 \cdot n\text{NH}_3$ (c). Ephraim and Bolle² measured the dissociation pressures of the tetra- and hexammines.

$\text{CuSO}_4 \cdot \text{Ti}_2\text{SO}_4 \cdot 6 \text{H}_2\text{O}$ (c). Caven and Ferguson¹ measured the dissociation pressures for the system, hexahydrate -dihydrate -water vapor.

SILVER

Ag (c). Standard state. Though both Berthelot¹²² and Petersen⁵ reported significant differences (1.2 and 3.2, respectively) between the heat contents of electrolytic and precipitated silver, modern evidence indicates that there is but one form of solid silver. Some of the observed

differences in heat content may be due to differences in the size of the crystals.

Ag (liq.). The data on the heat of fusion of silver are: Person,¹ -2.28; Umino,³ -2.69; Wust, Meuthen, and Durrer,¹ -2.8.

Ag (g). Vapor pressure data were reported by Greenwood,^{2, 3, 5, 6} Ruff and Bergdahl,¹ von Wartenberg,^{3, 7} Harteck,² and Jones, Langmuir, and Mackay.¹ van Liempt² reviewed the data. See also Piersol¹ and Tiede and Birnbrauer.¹ We have assumed gaseous silver to be monatomic.

The energy states of gaseous monatomic silver have been evaluated from the data of Fowler,³ Blair,¹ Kayser and Runge,¹ Randall,¹ Ritz,¹ Shenstone,^{1, 3} Fujioka and Nakamura,¹ White,¹ Frings,¹ McLennan and McLay,² Majumdar,¹ and Gibbs and White.¹

Ag⁺ (aq.). The value for this substance is obtained from those for AgNO₃ (aq.) and NO₃⁻ (aq.).

Ag₂O (c). Equilibrium data on the decomposition of silver oxide were reported by Lewis,⁴ Keyes and Hara,¹ and Benton and Drake.¹ Lewis and Randall⁵ calculated from the data of the first two investigations, $Q_f = 6.95$; while Benton and Drake¹ calculated $Q_f = 7.02$. Mixter's¹² data yield $Q_f = 6.2$. See also Biltz,⁸ Favre and Silbermann,² and Newton.¹

Ag₂O₂ (c). Jirsa^{2, 3, 4} measured the heats of solution of Ag₂O (c) and of Ag₂O₂ (c) in aqueous HClO₄ and aqueous HNO₃; and measured the heats of reduction of Ag₂O (c) and of Ag₂O₂ (c) with aqueous N₂H₂. His data yield, for Ag₂O₂ (c), $Q_f = 5.95$ and 6.4, respectively.

AgH (g). Farkas¹ studied the equilibrium, $2 \text{ Ag (c)} + \text{H}_2 \text{ (g)} = 2 \text{ AgH (g)}$, spectroscopically, and calculated $Q = 7.5$.

AgNO₃ (aq.). For the heat of solution of Ag₂O (c) in aqueous nitric acid, Jirsa¹ found 12.2 and Berthelot¹²⁸ 10.32; whence, for AgNO₃ (aq.), $Q_f = 24.5$ and 23.6, respectively. Thomsen's¹⁵ data on the reactions of Ba(OH)₂(400) with 2 AgNO₃(200) and with 2 HNO₃(200), $Q = 17.38$ and 28.28, respectively, yield, for AgNO₃(200), $Q_f = 23.83$. Lange and Fuoss¹¹ data on the reaction of AgNO₃(600) with KCl(660), $Q = 15.77^{25}$, yield, for AgNO₃(600), $Q_f = 23.92$. Thomsen's¹⁵ data on the reaction of AgNO₃(200) with KCl(200) and with HCl(200) yield $Q = 15.87$ and 15.75, respectively, whence, for AgNO₃(200), $Q_f = 23.99$ and 24.10. See also Berthelot¹² and Andre.¹ Berthelot,¹² Lange and Shibata,¹ and Thomsen¹⁵ measured the heat of reaction of aqueous silver nitrate with aqueous potassium iodide. The data of the latter two investigations yield, respectively, AgNO₃(1000), $Q_f = 24.22$, and AgNO₃(400), $Q_f = 24.36$. Jahn¹ obtained electromotive force data on the cell reaction of Pb (c) with 2 AgNO₃ (aq.). Data on the heat of dilution of aqueous silver nitrate were reported by Fricke and Havestadt.¹

AgNO₃ (c, II). The data on the heat of solution are Thomsen,¹⁵ -5.46₄₀₀; Berthelot,¹⁰ -5.7; Favre and Silbermann,¹⁰ -5.3; Bruni and Levi,² -5.3. See also Petersen.⁵

AgNO₃ (c, I). Bridgman^{6a} reported the heat of transition.

AgNO₃ (liq.). Magnus and Oppenheimer¹ reported the heat of fusion of silver nitrate.

AgCl (c). The electromotive force data of Gerke¹ and of Wolff² on the cell reaction, $\text{Ag (c)} + \frac{1}{2} \text{Cl}_2 \text{ (g)} = \text{AgCl (c)}$, yield $Q_f = 30.32$ and 30.16 , respectively. The electromotive force data on the cell reaction, $\text{Ag (c)} + \text{HgCl (c)} = \text{AgCl (c)} + \text{Hg (liq.)}$, yield the following values for Q : Brönsted,¹ -1.40 ; Gerke,¹ -1.276 ; Brönsted,^{2a} -1.30 ; Halle,² -1.40 . See also the electromotive force data of Gerke,¹ Brönsted,⁴ Halle,² and Krahmer¹ on the cell reaction, $2 \text{Ag (c)} + \text{PbCl}_2 \text{ (c)} = 2 \text{AgCl (c)} + \text{Pb (c)}$. See also Noyes and Ellis,¹ Harned and Brumbaugh,¹ Butler and Robertson,¹ Melcher,¹ and Rossini.¹⁰ Berthelot⁸⁶ and Lange and Fuoss¹ found the difference in energy content of the variously prepared forms of silver chloride to be small.

AgCl (liq.). The data on the heat of fusion are: Weber,¹ -4.4 ; Goodwin and Kalmus,¹ -3.06 .

AgCl (g). Vapor pressure data were reported by von Wartenberg and Bosse¹ and Maier.⁶ Brice¹ reported a value of -72.3 for the energy of dissociation of gaseous silver chloride at -273° , from spectroscopic data. The assumption that the dissociated atoms are in the normal state yields, for AgCl (g) , $Q_f = -24.7$.

AgI (c, II). Webb's^{1, 2} data on the direct combination of silver with iodine yield $Q_f = 14.94$. Webb's^{1, 2} data on the heats of dissolving, in concentrated aqueous KI, AgI (c) and $\text{Ag (c)} + \text{I}_2 \text{ (c)}$ yield, for AgI (c) , $Q_f = 15.01$. In similar experiments with aqueous KCN as the solvent, Webb's^{1, 2} found, for AgI (c) , $Q_f = 15.2$. From experiments similar to the latter Braune and Koref¹ found $Q_f = 15.1$. The electromotive force data yield the following values: Taylor and Anderson,¹ 15.13 ; Jones and Kaplan,¹ 14.35 ; Gerke,¹ 14.81 ; Taylor,² 15.15 . From the difference in the heats of solution of AgCl (c) and AgI (c) in aqueous KCN, the data of Fischer¹ and Wolff¹ yield, for AgI (c) , $Q_f = 15.1$ and 14.93 . See Bodlander² and Bernoulli.¹

AgI (c, I). The following are the data on the transition from II to I at 146° : Cohen and Joss,¹ -1.26 ; Mallard and LeChatelier,¹ -1.5 .

AgI (g). Jellinek and Rudat² computed the heat of vaporization from vapor pressure data. From the spectroscopic absorption limit and the assumption that the products of dissociation are a normal silver atom and an excited iodine atom, Franck and Kuhn¹ computed a value for the energy of dissociation of gaseous silver iodide which leads to the value $Q_f = -38$ for AgI (g) .

AgF (aq.). Petersen³ measured the heat of reaction of AgF (aq.) with HCl (aq.) to be 13.31 ; Guntz¹ that of AgF (aq.) with KOH (aq.) to be 17.6 .¹⁰

AgF (c). Guntz¹ measured the heat of solution.

AgF (amorphous, red). Guntz¹ measured the heat of solution.

AgF · $n\text{H}_2\text{O}$ (c). Guntz¹ measured the heat of solution of the tetrahydrate; Guntz and Guntz^{1, 2} those of the mono- and dihydrates.

AgHF₂ (aq.). Guntz¹ measured the heat of mixing AgF (aq.) + HF (aq.) to be 2.0.

Ag₂F (c). Guntz¹⁰ measured the heat of solution.

Ag₂Cl (c). Without giving details, Guntz¹¹ reported for the reaction, Ag (c) + AgCl (c) = Ag₂Cl (c), $Q = 0.5$.

AgClO₃ (aq.). The value for this substance is obtained from those for the ions.

AgClO₃ (c). Foote and Saxon¹ measured the heat of solution. See also Bedeau.¹

AgClO₄ (aq.). Jirsa¹ found the heats of reaction of AgClO₄ (aq.) with HCl (aq.), HBr (aq.), and HI (aq.), respectively, to be 15.75, 20.52, and 26.87. Jirsa¹ also measured the heat of reaction of Ag₂O (c) with concentrated HClO₄ (aq.).

AgClO₄ (c). Bruni and Levi² measured the heat of solution.

AgBr (c). Webb's^{1, 2} electromotive force data on the reaction, Ag (c) + $\frac{1}{2}$ Br₂ (liq.) = AgBr (c), yield $Qf = 23.81$. Krahmer's¹ electromotive force data on the reaction, AgI (c) + $\frac{1}{2}$ PbBr₂ (c) = AgBr (c) + $\frac{1}{2}$ PbI₂ (c), yield, for AgBr (c), $Qf = 24.16$. See also Klein¹ and Bernoulli.¹ Berthelot¹² and Thomsen¹⁵ measured the heat of reaction of aqueous silver nitrate with aqueous hydrobromic acid. The latter's data yield, for AgBr (c), $Qf = 23.68$.

AgBr (g). Jellinek and Rudat² computed the heat of vaporization from vapor pressure data.

AgBr (liq.). We have estimated the heat of fusion.

3 AgI · HI · 7 H₂O (c). Berthelot⁶⁹ measured the heat of solution.

AgI₃⁻ (aq.). Webb¹ measured the heat of solution of silver iodide in concentrated aqueous potassium iodide to be 1.8. See also Berthelot.¹⁵¹

Ag₂S (c, II). Thomsen's¹⁵ data on the reaction of 2 AgNO₃ (100) with Na₂S (200) yield, for Ag₂S (c, II), $Qf = 6.86$. Berthelot's^{14, 133} data on the similar reaction with H₂S (aq.) yield $Qf = 5.0$. Equilibrium data on the reaction, Ag₂S (c) + H₂ (g) = H₂S (g) + 2 Ag (c), were reported by Jellinek and Zakowski,¹ Pelabon,³ Keyes and Felsing,¹ and Watanabe.¹ The latter calculated $Qf = 5.1$. See also Jellinek and Podjaski¹ and Noyes and Freed.¹

Ag₂S (c, I). Bellati and Lussana¹ reported the heat of transition.

Ag₂SO₄ (aq.). Thomsen's¹⁵ data on the reaction of Ag₂SO₄ (aq.) with 2 KOH (aq.) yield, for Ag₂SO₄ (aq.), $Qf = 165.27$. See also Berthelot.¹²⁸

Ag₂SO₄ (c). From indirect measurements, Thomsen¹⁵ reported the heat of solution to be -4.48. Thomsen's¹⁵ data on the reaction of 2 AgNO₃ (100) with (NH₄)₂SO₄ (100) yield -4.58 for the heat of solution of silver sulfate. See also Marchal.³

Ag(S₂O₃)₂⁻ (aq.). Fogh¹ measured the heat of reaction of aqueous silver nitrate with excess aqueous sodium thiosulfate to be 20.0.

Ag₂S₂O₆ (aq.). The value for this substance is obtained from the ions.

$\text{Ag}_2\text{S}_2\text{O}_6 \cdot 2 \text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

Ag_2Se (c, II). Fabre² measured the heats of reaction of silver selenide with bromine water and of aqueous silver acetate with gaseous hydrogen selenide. See also Pelabon¹ and Tubandt and Reingold.¹

Ag_2Se (c, I). Bellati and Lussana¹ reported the heat of transition.

Ag_2SeO_4 (c). Metzner^{1, 2} measured the heat of reaction of aqueous silver nitrate with aqueous potassium selenate to be 8.48.

AgN_3 (c). Wohler and Martin¹ measured the heat of decomposition of silver azide to be 67.3.

AgNO_2 (aq.). Berthelot^{9, 10, 28} reported a value for the heat of neutralization of nitrous acid with silver oxide.

AgNO_2 (c). Berthelot^{9, 10, 28} measured the heat of solution.

$\text{Ag}_2\text{N}_2\text{O}_2$ (c). Berthelot and Ogier⁷ reported a value for the heat of neutralization of hyponitrous acid with silver oxide.

$\text{Ag}_2\text{O}_2 \cdot \text{HNO}_3 \cdot 2 \text{H}_2\text{O}$ (liq.). Jirsa² reported a value for the heat of formation of this substance.

$\text{AgNO}_3 \cdot n\text{NH}_3$ (aq.). Bruni and Levi¹ measured the heat of mixing AgNO_3 (100) with 2NH_3 (1100) to be 12.79, and found no evolution of heat on the addition of more ammonia. For the same reaction, Berthelot and Delepine² found $Q = 13.39$. These investigators also measured the heat of reaction of $\text{AgNO}_3 \cdot 2 \text{NH}_3$ (aq.) with aqueous nitric acid to be 11.64 and 12.25, respectively. Bruni and Levi² measured the heat of reaction of the aqueous triammine with aqueous nitric acid to be 24.01.

$\text{AgNO}_3 \cdot 2 \text{NH}_3$ (c). The data on the heat of solution are: Bruni and Levi,² -9.05; Berthelot and Delepine,² -8.97; Jirsa and Diamant,¹ -9.23.

$\text{AgNO}_3 \cdot \text{NH}_3$ (c). Data on the dissociation pressure of the system, diammine-monoammine- NH_3 (g), were reported by Ephraim.⁴ See also Joannis and Crozier¹ and Lemoult.¹

$\text{AgNO}_3 \cdot 3 \text{NH}_3$ (c). For the heat of solution Bruni and Levi² found -10.44 in water, Jirsa and Diamant¹ -9.23 in aqueous nitric acid. Data on the dissociation pressure of the triammine were reported by Ephraim.⁴ See also Joannis and Crozier¹ and Lemoult.¹

$\text{AgClO}_4 \cdot n\text{NH}_3$ (aq.). Bruni and Levi² measured the heat of mixing aqueous silver perchlorate with aqueous ammonia.

$\text{AgClO}_4 \cdot n\text{NH}_3$ (c). Bruni and Levi² measured the heats of solution of the di- and triammines.

$\text{Ag}(\text{NH}_3)_2^+$ (aq.). The value for this substance is obtained from those for $\text{AgNO}_3 \cdot 2 \text{NH}_3$ (aq.) and NO_3^- (aq.).

$\text{AgX} \cdot n\text{NH}_3$ (c). Isambert⁵ reported values for the heats for formation of $\text{AgCl} \cdot 3 \text{NH}_3$ (c) and of $\text{AgCl} \cdot 1\frac{1}{2} \text{NH}_3$ (c), computed from unpublished values for the heats of solution. The dissociation pressure data of Biltz and Stollenwerk¹ yield values for the amines of AgCl with 1, $1\frac{1}{2}$, and 3 NH_3 , for those of AgBr with 1, $1\frac{1}{2}$, and 3 NH_3 , and for those of AgI with $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, and 3 NH_3 . See also Jarry,¹ Bonnefoi,¹ and Joannis and Crozier.¹

AgBrO₃ · 3 NH₃ (c). Ephraim⁴ obtained dissociation pressure data on this ammine.

AgNO₂ · 3 NH₃ (c). Ephraim⁴ obtained dissociation pressure data on this ammine.

Ag₂C₂ (c). Berthelot and Delepine¹ measured the heat of reaction of acetylene with 2 AgNO₃ · 2 NH₃ (c), and the heat of solution of Ag₂C₂ (c) in aqueous silver nitrate.

Ag₂C₂ · nAgCl (c). Berthelot and Delepine¹ measured the heats of solution of Ag₂C₂ · AgCl (c) and of Ag₂C₂ · $\frac{1}{2}$ AgCl (c) in aqueous HCl.

Ag₂C₂ · nAgI (c). Berthelot and Delepine¹ measured the heats of solution in aqueous HCl of Ag₂C₂ · AgI (c) and of Ag₂C₂ · 2 AgI (c).

Ag₂C₂ · $\frac{1}{2}$ Ag₂SO₄ (c). Berthelot and Delepine¹ measured the heat of solution in aqueous HCl.

Ag₂C₂ · AgNO₃ (c). Berthelot and Delepine¹ measured the heat of solution in aqueous HCl.

Ag₂CO₃ (c). Berthelot's¹² data on the reaction of aqueous silver nitrate with aqueous potassium carbonate yield $Q_f=117$ for the freshly precipitated silver carbonate, and $Q_f=121$ for the crystallized material. The equilibrium data of Centnerszwer and Krustinson¹ on the reaction, Ag₂CO₃ (c) = Ag₂O (c) + CO₂ (g), yield, for Ag₂CO₃ (c), $Q_f=119.9$.

Ag₂C₂O₄ (c). Berthelot¹⁰ measured the heat of reaction of aqueous silver nitrate with aqueous potassium oxalate to be 14.6.

AgC₂H₃O₂ (aq.). Berthelot⁹ reported a value for the heat of neutralization of silver oxide with aqueous acetic acid.

AgC₂H₃O₂ (c). The data on the heat of solution are: Berthelot,⁹ -4.3; van Laar,¹⁰ -4.41; Goldschmidt and van Maarsevenn,¹ -4.37. See also Rudolphi.¹

AgCN₂⁻ (aq.). The value for this substance is obtained from those for the aqueous salts.

AgCN (c). Thomsen¹⁵ measured the heats of the reactions, AgNO₃ (200) + 2 KCN (200) = (KAg(CN)₂ + KNO₃) (600) and KAg(CN)₂ (600) + AgNO₃ (200) = KNO₃ (800) + 2 AgCN (c), to be 33.21 and 20.22, respectively.

Ag(CN)₃⁻ (aq.). Varet⁵ measured the heat of solution of silver cyanide in various aqueous cyanides.

AgCN · NH₃ (c). Joannis and Crozier¹ reported $D = -14.0$.

AgCNO (c). Lemoult¹ measured the heat of the reaction, KCNO (aq.) + AgNO₃ (aq.) = KNO₃ (aq.) + AgCNO (c), to be 13.46.

Ag₂CN₂ (c). Lemoult¹ measured the heat of solution in aqueous HCl.

AgONC (c). Wohler and Martin¹ measured the heat of decomposition of silver fulminate into Ag (c) + $\frac{1}{2}$ N₂ (g) + CO (g) to be 69.6.

AgCNS (c). Joannis¹ measured the heat of the reaction, HCNS (aq.) + AgNO₃ (aq.) = HNO₃ (aq.) + AgCNS (c), to be 22.44.

AgCNS (aq.). Kirschner's¹ data on the temperature coefficient of the solubility yield -21.3 for the heat of solution.

AgX · CH₃NH₂ (c). Jarry¹ obtained dissociation pressure data on

the monomethylamines of silver chloride, silver bromide, and silver iodide.

AgI · PbI₂ (c). Bellati and Romanese² measured the heat of transition.

AgI · nCuI (c). Bellati and Romanese² measured the heat of transition of these compounds with $n=1$ and 2.

Ag₃Hg₄ (c). Data on the silver amalgams were reported by Berthelot¹²³ and Littleton.¹

GOLD

Au (c). Standard state.

Au (liq.). For the heat of fusion at its melting point, 1063°, Wust, Meuthen, and Durrer¹ reported -3.13 and Umino³ -3.11 .

Au (g). The vapor pressure data of Ruff and Bergdahl,¹ Tiede and Birnbauer,¹ and von Wartenberg³ yield -86 for the heat of vaporization at 2611°. The energy states of gaseous monatomic gold are evaluated from the data of McLennan and McLay.¹

AuCl (c). Fischer and Biltz¹ measured the heats of solution of Cl₂ (g), Au (c), and AuCl (c) in aqueous ICl₃ to be 7.1, 18.5, and 17.2, respectively; whence, for AuCl (c), $Q_f=8.4$. The dissociation pressure data of Fischer and Biltz¹ and of Ephraim⁶ yield, for AuCl (c), $Q_f=8.8$ and 8.25, respectively. See also Matignon⁹ and Meyer.^{1a}

AuCl₃ (c). Fischer and Biltz¹ measured the heats of solution in aqueous ICl₃ of Cl₂ (g), Au (c), and AuCl₃ (c), and their data yield, for the latter, $Q_f=28.3$. The dissociation pressure data of Fischer and Biltz,⁷ Petit,² and Pellaton¹ yield, for AuCl₃ (c), $Q_f=28.1$, 26.6, and 29.5.

AuBr (c). Fischer and Biltz¹ measured the heats of solution of Au (c), Br₂ (liq.), and AuBr (c) in aqueous ICl₃, their data yielding, for AuBr (c), $Q_f=3.4$. Thomsen¹⁵ measured the heat of solution of AuBr (c) in HBr (aq.) to be 1.20 and in H₂SO₃ (aq.) to be 21.38; whence, for AuBr (c), $Q_f=5.0$ and 5.8. Fischer and Biltz¹ studied the equilibrium, AuBr (c) + Br₂ (g) = AuBr₃ (c), and found $Q=17 \pm 2$. See also Ephraim,⁶ Meyer,¹ and Petersen.^{1, 2}

AuBr₃ (c). Fischer and Biltz¹ measured the heats of solution of Au (c), Br₂ (liq.), and AuBr₃ (c) in aqueous ICl₃, their data yielding, for AuBr₃ (c), $Q_f=14.5$.

AuBr₃ (aq.). Thomsen¹⁵ measured the heat of solution of AuBr₃ (c) to be -3.76_{200} .

AuCl₃ (aq.). Thomsen¹⁵ measured the heat of reaction of 2 AuCl₃ (1500) with 3 SO₂ (500) to be 83.60; whence, for AuCl₃ (aq.), $Q_f=29.78$. Thomsen¹⁵ measured the heat of solution of AuCl₃ in water to be 4.45₉₀₀. Combination with Fischer and Biltz's¹ value for AuCl₃ (c) yield, for AuCl₃ (aq.), $Q_f=32.75$.

AuCl₃ · 2 H₂O (c). Fischer and Biltz¹ measured the heat of solution.

HAuCl₄ (aq.). Thomsen¹⁵ and Fischer and Biltz¹ measured the heat of solution of AuCl₃ (c) in aqueous HCl to be 8.98 and 10.1, respectively. Using 28.3 as the value for AuCl₃ (c), one obtains, for HAuCl₄ (aq.),

$Qf=76.7$ and 77.8 . Thomsen¹⁵ and Fischer and Biltz¹ measured the heat of the reaction, $3 \text{ AuCl (c)} + \text{HCl (aq.)} = \text{HAuCl}_4 \text{ (aq.)} + 2 \text{ Au (c)}$, to be 5.0 and 13.5 , respectively; whence, for $\text{HAuCl}_4 \text{ (aq.)}$, $Qf=69.4$ and 77.8 . Thomsen¹⁵ explained the difference in his two values by assuming that the gold formed in the latter reaction has an energy content of about 5 greater than that of ordinary gold; but there is no other evidence to support this view.

$\text{HAuCl}_4 \cdot n\text{H}_2\text{O (c)}$. Thomsen¹⁵ measured the heats of solution of the tri- and tetrahydrates.

$\text{AuCl}_2 \text{ (c)}$. Fischer and Biltz¹ and Petersen^{1, 2} measured the heat of solution of this supposed compound to be, respectively, 6.75 in HCl(100) and 5.15 in HCl(900) . These data yield, for $\text{AuCl}_2 \text{ (c)}$, $Qf=18.1$ and 19.7 , respectively. One-half the sum of the values for AuCl (c) and $\text{AuCl}_3 \text{ (c)}$ is 18.3 .

$\text{HAuBr}_4 \text{ (aq.)}$. Thomsen¹⁵ measured the heat of mixing $\text{AuBr}_3 \text{ (aq.)}$ with HBr (aq.) to be 7.70 ; whence, for $\text{HAuBr}_4 \text{ (aq.)}$, $Qf=47.1$.

$\text{HAuBr}_4 \cdot 5 \text{ H}_2\text{O (c)}$. Thomsen¹⁵ measured the heat of solution.

AuI (c) . Thomsen¹⁵ measured the heat of the reaction, $\text{AuCl}_3 \text{ (aq.)} + 3 \text{ KI (aq.)} = \text{AuI (c)} + 3 \text{ KCl (aq.)} + \text{I}_2 \text{ (c)}$, to be 45.66 ; whence, for AuI (c) , $Qf=-0.3$. Thomsen¹⁵ also measured the heat of the reaction of aurous iodide with aqueous sulfur dioxide. Fischer and Biltz¹ measured the heats of solution in aqueous ICl_3 of Au (c) , $\text{I}_2 \text{ (c)}$, and AuI (c) , and their data yield, for AuI (c) , $Qf=-0.2$.

$\text{Au(OH)}_3 \text{ (c)}$. Thomsen¹⁵ measured the heat of solution in 4 HBr (aq.) and in 4 HCl (aq.) .

$\text{Au}_2\text{O}_3 \text{ (c)}$. Mixer's¹² data on the heats of the reactions of $3 \text{ Na}_2\text{O}_2 \text{ (c)}$ with 2 Au (c) and with $\text{Au}_2\text{O}_3 \text{ (c)}$, yield, for the latter, $Qf=-11$.

AuH (g) . From band spectra, Bengtsson and Hulthen¹ calculated $D^\circ = -103.5$. See also Farkas.¹

$\text{Au(CN)}_2^- \text{ (aq.)}$. Biltz^{6a, 6b} measured the heats of solution of AuI (c) , AuBr (c) , and AuCl (c) in aqueous cyanide solutions, and his data yield, for $\text{Au(CN)}_2^- \text{ (aq.)}$, $Qf=-58.0$, -56.8 , and -57.5 .

$\text{AuHg}_{100} \text{ (liq.)}$. Data on the heat of formation of gold amalgam were reported by Biltz and Meyer² and Tammann and Ohler,¹ who found, for $\text{AuHg}_{100} \text{ (liq.)}$, $Qf=-1.3$ and -2.0 , respectively.

$\text{AuAgCl}_2 \text{ (c)}$. We have estimated the heat of formation of this substance from AgCl (c) and AuCl (c) to be zero.

$\text{AuAgCl}_4 \text{ (c)}$. Parravano and Malquori³ studied the equilibrium, $\text{AuAgCl}_4 \text{ (c)} = \text{Cl}_2 \text{ (g)} + \text{AuAgCl}_2 \text{ (c)}$, and calculated $Q=18.6$.

$\text{AuCl} \cdot n\text{NH}_3 \text{ (c)}$. Biltz^{6a, 6b} measured the heats of solution of the mono- and diammines in aqueous KCN, and obtained dissociation pressure data on the di- and hexammines. Ephraim⁶ measured the dissociation pressures of the diammine.

$\text{AuBr} \cdot n\text{NH}_3 \text{ (c)}$. Biltz^{6a, 6b} measured the heats of solution of the mono- and diammines in aqueous KCN, and obtained dissociation pressure data on the di-, tri-, tetra-, and hexammines.

AuI · nNH₃ (c). Biltz^{6a, 6b} measured the heat of solution of the mono-amine, and obtained dissociation pressure data on the di-, tri-, hexa-, and octammines.

PLATINUM

Pt (c). Standard state.

Pt (g). Jones, Langmuir, and Mackay¹ calculated the heat of sublimation of platinum to be -127 , from the rate of loss of the metal from a hot platinum wire. See also Langmuir and Mackay² and van Liempt.² The energy states of gaseous monatomic platinum have been evaluated from the data of Livingood.¹

Pt (liq.). Violle¹ measured the heat of fusion.

H₂PtCl₆ (aq.). Thomsen's¹⁵ data on the heat of neutralization of H₂PtCl₆ (600) with 2 NaOH (300) yield $Q = 27.02$; whence, for H₂PtCl₆ (600), $Q_f = 166.2$. Pigeon's¹ data on the reaction of H₂PtCl₆ (aq.) with solid cobalt yield, for H₂PtCl₆ (aq.), $Q_f = 152.7$, which value is quite divergent. Pigeon¹ measured the heats of the following reactions: PtCl₄ (aq.) + 2 Co (c) = 2 CoCl₂ (aq.) + Pt (c), $Q = 110.1$; PtCl₄ (c) = PtCl₄ (aq.), $Q = 19.56$; PtCl₄ (c) + 2 HCl (aq.) = H₂PtCl₆ (aq.), $Q = 24.8$. Combination of these data yields, for H₂PtCl₆ (aq.), $Q_f = 165.6$. Combination of Thomsen's¹⁵ data on the heat of the reaction, Na₂PtCl₆ (aq.) + 2 CuCl (c) = (Na₂PtCl₄ + 2 CuCl₂) (aq.), with his data on the heat of neutralization of H₂PtCl₆ (aq.) with 2 NaOH (aq.) yields, for H₂PtCl₆ (aq.), $Q_f = 166.1$.

PtCl₆⁻ (aq.). The value for this substance is obtained from those for the aqueous sodium and potassium salts. Miller and Terrey¹ obtained electromotive force data on the cell reaction, 2 Hg (liq.) + PtCl₆⁻ (aq.), = 2 HgCl (c) + PtCl₄⁻ (aq.), which give $Q = 21.71$; whence, for the reaction, PtCl₄⁻ (aq.) + Cl₂ (g) = PtCl₆⁻ (aq.), $Q = 41.4$.

HPtCl₅ · 2 H₂O (c). Pigeon¹ measured the heat of solution in aqueous HCl.

H₂PtCl₆ · 6 H₂O (c). Pigeon¹ measured the heat of solution in aqueous HCl.

H₂PtCl₄ (aq.). The heat of neutralization of H₂PtCl₄ (aq.) with 2 NaOH (aq.) is assumed to be the same as that for H₂PtCl₆ (aq.).

PtCl₄⁻ (aq.). This value is obtained from those for the aqueous sodium and potassium salts.

PtCl_n (c). Pigeon¹ measured the heat of solution of PtCl₄ (c) in water to be 19.56, and in 2 HCl (aq.) to be 24.8. Wohler and Streicher² obtained dissociation pressure data on PtCl (c), PtCl₂ (c), PtCl₃ (c), and PtCl₄ (c).

PtCl₄ · 5 H₂O (c). Pigeon¹ measured the heat of solution.

Pt(OH)₂ (c). Thomsen¹⁵ measured the heat of reduction of this substance with aqueous formic acid to be 48.3; whence, for Pt(OH)₂ (c), $Q_f = 87.5$.

H₂PtBr₆ (aq.). Pigeon's¹ data on the reactions of PtBr₄ (aq.) with 2 Co (c), of PtBr₄ (c) with water, and of PtBr₄ (c) with 2 HBr (aq.),

yield, for H_2PtBr_6 (aq.), $Qf=119.8$. Thomsen's¹⁵ data on the platinous salts together with the heat of oxidation with liquid bromine yield $Qf=115.3$. From the values for Na_2PtBr_6 (aq.) and K_2PtBr_6 (aq.) and the heat of neutralization of H_2PtBr_6 (aq.) with 2 NaOH (aq.) or 2 KOH (aq.) (assumed to be the same as that for H_2PtCl_6 (aq.)), one obtains, for H_2PtBr_6 (aq.), $Qf=116.2$ and 115.5 .

PtBr_6^- (aq.). This value is obtained from those for the aqueous sodium and potassium salts.

$\text{H}_2\text{PtBr}_6 \cdot 9 \text{H}_2\text{O}$ (c). Pigeon¹ measured the heat of solution.

PtBr_4 (aq.). Pigeon¹ measured the heat of reduction of this substance with 2 Co (c) to be 93.5.

PtBr_4 (c). Pigeon¹ measured the heat of solution of this substance in water to be 9.86, and in 2 HBr (aq.) to be 18.27.

PtBr_4^- (aq.). The value for this substance is obtained from that for K_2PtBr_4 (aq.).

PtI_4 (c). Pigeon¹ measured the heat of reaction of this substance with 2 NaI (aq.) to be 7.3.

PtI_6^- (aq.). This value is obtained from that for Na_2PtI_6 (aq.).

PtS (c), PtS_2 (c). Biltz and Jirsa¹ obtained dissociation pressure data on these sulfides.

$\text{Pt}(\text{NH}_3)_4\text{Cl}_2 \cdot \text{H}_2\text{O}$ (c). We have estimated the heat of formation of this hydrate from that for $\text{PtCl}_2 \cdot 4 \text{NH}_3$ (c).

$\text{Pt}(\text{NH}_3)_4\text{Cl}_2$ (aq.). Thomsen¹⁵ measured the heat of solution of $\text{Pt}(\text{NH}_3)_4\text{Cl}_2 \cdot \text{H}_2\text{O}$ (c) in water.

$\text{Pt}(\text{NH}_3)_4(\text{OH})_2$ (aq.). Thomsen¹⁵ measured the heat of reaction of this substance with 2 HCl (aq.) to be 27.3.

$\text{Pt}(\text{NH}_3)_4\text{SO}_4$ (aq.). Thomsen¹⁵ measured the heat of reaction of $\text{Pt}(\text{NH}_3)_4(\text{OH})_2$ (aq.) with H_2SO_4 (aq.) to be 30.85.

$(\text{NH}_4)_2\text{PtCl}_4$ (aq.). The value for this substance is obtained from those for NH_4^+ (aq.) and PtCl_4^- (aq.).

$(\text{NH}_4)_2\text{PtCl}_4$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{PtCl}_2 \cdot n\text{NH}_3$ (c). Isambert¹ reported a value for the heat of formation of the diammine. Ephraim and Millman¹ obtained dissociation pressure data on the tetra- and pentammines.

$\text{PtI}_2 \cdot n\text{NH}_3$ (c). Ephraim and Millman¹ obtained dissociation pressure data on the tetra- and hexammines.

Ag_2PtCl_6 (c). Pigeon¹ measured the heat of reaction of H_2PtCl_6 (aq.) with 2 AgNO_3 (aq.) to be 14.55.

Ag_2PtBr_6 (c). Pigeon¹ measured the heat of reaction of H_2PtBr_6 (aq.) with 2 AgNO_3 (aq.) to be 32.0.

$[\text{Pt} \cdot 6 \text{NH}_3]^{+++}$ (aq.), $[\text{Pt} \cdot 5 \text{NH}_3 \cdot \text{NH}_2]^{+++}$ (aq.), $[\text{Pt} \cdot 5 \text{NH}_3 \cdot \text{Cl}]^{+++}$ (aq.), $[\text{Pt} \cdot 4 \text{NH}_3 \cdot \text{NH}_2 \cdot \text{Cl}]^{++}$ (aq.). See Grunberg and Faermann.¹

Ir (c). Standard state. IRIDIUM

Ir (g). We have estimated the heat of sublimation to be -120 . See Meggers and Laporte¹ for the energy states of gaseous monatomic iridium.

IrO₂ (c). From their vapor pressure data, Wohler and Witzmann¹ calculated $Qf=50$; Biltz¹ computed $Qf=52$ from the same data.

IrCl_n (c). Wohler and Streicher¹ obtained dissociation pressure data on IrCl (c), IrCl₂ (c), and IrCl₃ (c).

IrCl₆⁻ (aq.). The value for this substance is obtained from those for K₂IrCl₆ (aq.) and K⁺ (aq.).

IrCl₆⁻ (aq.). The values for K₃IrCl₆ (aq.) and K⁺ (aq.) yield, for IrCl₆⁻ (aq.), $Qf=187.2$. The electromotive force data of Terrey and Baker¹ on the cell reaction, Hg (liq.) + Cl⁻ (aq.) + IrCl₆⁻ (aq.) = HgCl (c) + IrCl₆⁻ (aq.), yield $Q=25.7$; whence, for IrCl₆⁻ (aq.), $Qf=186.3$.

IrF₆ (liq.). For the heat of formation of this substance, Ruff and Fischer¹ reported the approximate value 130.

IrF₆ (g). Ruff and Fischer¹ reported $V=-8.50$.

OSMIUM

Os (c). Standard state.

Os (g). We have estimated the heat of sublimation to be -125 . See Meggers and Laporte¹ concerning the energy states of gaseous monatomic osmium.

OsO₄ (c). von Wartenberg¹ determined the heat of combustion of osmium to form the tetroxide.

OsO₄ (liq.). von Wartenberg¹ found the heat of fusion to be -3.41 at 40° .

OsO₄ (g). von Wartenberg's¹ data yield -13.5 for the heat of sublimation of solid osmium tetroxide.

RHENIUM

Re (c). Standard state.

ReO₃ (c), Re₂O₇ (c). Roth and Becker^{4, 5} measured the heat of combustion of rhenium (97.9 to 98.9% pure) in oxygen to form a mixture of the two oxides. The amount of rhenium burned to the lower oxide ranged from 1.5 to 13.8%, and that to the higher oxide ranged from 86 to 98%. These investigators calculated, for Re₂O₇ (c), $Qf=297.5 \pm 2.0$, and for ReO₃ (c), $Qf=82.5 \pm 8.0$.

HReO₄ (aq.). Roth and Becker⁴ measured the heat of solution of Re₂O₇ (c) in water at 20° at concentrations ranging from 9370 to 46,350 H₂O. For 9370 H₂O, $Q=11.23$, whence, for HReO₄(4700), $Qf=222.73$.

We have estimated values for the heat of dilution of aqueous HReO₄ from the above data of Roth and Becker.

ReO₄⁻ (aq.). This value is obtained from that for HReO₄ (∞).

PALLADIUM

Pd (c). Standard state.

Pd (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic palladium are from McLennan and Smith¹ and Shenstone.^{1c, 4}

Pd (liq.). Violle^{1a} measured the heat of fusion.

PdO (c). Biltz⁸ computed the heat of formation of this substance from the dissociation pressure data of Wohler.¹

Pd₂H (c). The data on the heat of formation of this compound are: Gillespie and Hall,¹ 8.86; Gillespie and Ambrose,¹ 9.28; Favre,⁹ 8.9. See also Moutier.¹

Pd(OH)₂ (c). Thomsen¹⁵ measured the heat of reaction of Na₂PdCl₄ (aq.) with 2 NaOH (aq.) to be 12.55; Joannis⁴ measured the heat of reaction of K₂PdBr₄ (aq.) with 2 KOH (aq.) to be 9.02. These data yield, for Pd(OH)₂ (c), $Q_f = 90.7$ and 89.1 , respectively.

Pd(OH)₄ (c). Thomsen¹⁵ measured the heat of reaction of K₂PdCl₆ (aq.) with 4 NaOH (aq.) to be 18.01; whence, for Pd(OH)₄ (c), $Q_f = 155.0$.

PdCl₂ (c). Joannis⁴ found $Q = 4.72$ for the reaction, PdCl₂ (c) + 2 KCl (aq.) = K₂PdCl₄ (aq.); while, for that with 2 HCl (aq.), Thomsen¹⁵ found $Q = 4.0$. These data yield, for PdCl₂ (c), $Q_f = 43.5$ and 44.2 , respectively.

PdCl₄⁻ (aq.). This value is obtained from that for K₂PdCl₄ (aq.).

PdCl₆⁻ (aq.). This value is obtained from that for K₂PdCl₆ (aq.).

H₂PdCl₆ (aq.). We have assumed the heat of ionization to be zero.

H₂PdCl₄ (aq.). Thomsen¹⁵ measured the heat of neutralization of this acid with 2 NaOH (aq.) to be 27.25.

PdBr₂ (c). Joannis⁴ reported $Q_f = 24.9$.

PdBr₄⁻ (aq.). This value is obtained from that for K₂PdBr₄ (aq.).

PdI₂ · H₂O (c). Joannis⁴ measured the heat of reaction of K₂PdBr₄ (aq.) with 2 KI (aq.) to form PdI₂ · H₂O (c) + 4 KBr (aq.) to be 18.40. For the reaction of K₂PdCl₄ (aq.) with 2 KI (aq.), Thomsen¹⁵ found $Q = 22.56$. These data yield, for PdI₂ · H₂O (c), $Q_f = 84.3$ and 86.5 .

PdI₂ (c). We have estimated the heat of dissociation of the monohydrate.

Pd(CN)₂ (c). Joannis⁴ measured the heat of reaction of K₂PdBr₄ (aq.) with 2 KCN (aq.) to be 47.14; whence, for Pd(CN)₂ (c), $Q_f = -51.7$.

PdX₂ · nNH₃ (c). Isambert⁶ reported values for the heats of formation of the di- and tetrammines of the chloride and bromide.

RHODIUM

Rh (c). Standard state.

Rh (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic rhodium are from Bacher and Goudsmit.¹

Rh_nO_m (c). Wohler and Muller² obtained dissociation pressure data on RhO (c), Rh₂O (c), and Rh₂O₃ (c), from which we have estimated the heats of formation.

RhCl_n (c). Wohler and Muller² obtained dissociation pressure data on RhCl (c), RhCl₂ (c), and RhCl₃ (c), from which we have estimated the heats of formation.

RhCl₆⁻ (aq.). The value for this substance is obtained from that for Na₃RhCl₆ (aq.).

RUTHENIUM

Ru (c). Standard state.

Ru (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic ruthenium are from Bacher and Goudsmit.¹

RuO₂ (c). Remy and Kohn¹ obtained dissociation pressure data on this substance.

RuCl₃ (c). Remy and Kohn¹ obtained dissociation pressure data on RuCl₃ (c). See also Wohler and Balz.¹

MASURIUM

Ma (c). Standard state.

NICKEL

Ni (c, III). Standard state.

Ni (c, II). For the heat of transition at the Curie point, 360°, the data are: Weiss, Piccard, and Carard,¹ -0.17; Laschtschenko,² -0.12; Wust, Meuthen, and Durrer,¹ -0.08; Umino,⁴ -0.12; Laschtschenko,⁵ -0.18. See also Pionchon,² Werner,¹ and Klinkhardt.¹

Ni (c, I). There is supposed to be a transition at about 1130°, but the heat effect must be small as it has not been observed.

Ni (liq.). For the heat of fusion of nickel at 1452°, White¹ reported -4.34 and Umino⁴ -4.07.

Ni (g). Jones, Langmuir, and Mackay¹ calculated the heat of sublimation of nickel to be -89.4; Millar¹ calculated the value -88.2; we have estimated the value -85.0. The energy states of gaseous monatomic nickel are evaluated from the data of Russell,⁶ Menzies,⁴ and Shenstone.²

NiO (c). The data on the heat of combustion of nickel to form NiO (c) are: Roth,⁵ 58.9; Mixter,¹¹ 57.9; Ruff and Gersten,⁴ 53; Dulong,² 59.7. Equilibrium data involving NiO (c) were obtained by Treadwell,¹ Watanabe,^{1b} Pease and Cook,¹ Skapski and Dabrowski.¹ See also Wohler and Balz² and Foote and Smith.¹

Ni(OH)₂ (c, ppt.). Thomsen¹⁵ measured the heat of the reactions of NiSO₄(400) with Ba(OH)₂(400) and of NiSO₄(100) with 2 NaOH (100) to be 10.63 and 5.33, respectively; whence, for Ni(OH)₂ (c, ppt.) $Q_f = 129.8$ and 129.8 . Giordani and Mattias^{1, 8} measured the heat of solution of Ni(OH)₂ (c) in aqueous HCl and in aqueous H₂SO₄ to be 20.65 and 22.16, respectively; whence, for Ni(OH)₂ (c), $Q_f = 131$ and 133 .

Ni(OH)₃ (c, ppt.). Thomsen¹⁵ measured the heat of the reaction, 2 NiCl₂ (aq.) + NaOCl (aq.) + H₂O (liq.) + 4 NaOH (aq.) = 2 Ni(OH)₃ (c, ppt.) + 5 NaCl (aq.), and his data yield, for Ni(OH)₃ (c, ppt.), $Q_f = 163.2$. Giordani and Mattias^{1, 8} measured the heat of solution of Ni(OH)₃ (c) in aqueous H₂SO₄ to be 39.7.

NiF₂ (aq.). Petersen¹ measured the heat of reaction of NiCl₂ (aq.) with 2 AgF (aq.) to be 31.71; whence, for NiF₂ (aq.), $Q_f = 171.4$. Mulert¹

measured the heat of solution of $\text{Ni(OH)}_2(\text{c})$ in aqueous (20%) HF to be 28.0.

$\text{NiF}_2(\text{c})$. The equilibrium data of Jellinek and Rudat¹ on the reaction, $\text{NiF}_2(\text{c}) + \text{H}_2(\text{g}) = 2\text{HF}(\text{g}) + \text{Ni}(\text{c})$, yield, for $\text{NiF}_2(\text{c})$, $Q_f^{\text{600}} = 157.5$.

$\text{NiCl}_2(\text{aq.})$. Thomsen¹⁵ found $Q = 15.17$ for the heat of solution of $\text{Ni}(\text{c})$ in $2\text{HCl}(400)$; whence, for $\text{NiCl}_2(800)$, $Q_f = 94.23$. Data on the heat of dilution of aqueous NiCl_2 were reported by Thomsen.¹⁵

$\text{NiCl}_2(\text{c})$. Thomsen¹⁵ measured the heat of solution.

$\text{NiCl}_2 \cdot \text{H}_2\text{O}(\text{c})$. Sabatier² measured the heat of solution.

$\text{NiCl}_2 \cdot 4\text{H}_2\text{O}(\text{c})$. Dissociation pressure data on the system, hexahydrate-tetrahydrate-water vapor, were obtained by Derby and Yngve¹ and Lescoeur.²

$\text{NiCl}_2 \cdot 6\text{H}_2\text{O}(\text{c})$. Thomsen¹⁵ measured the heat of solution. See also Berger and Crut,¹ Jellinek and Podjaski,¹ and Jellinek and Uloth¹ for equilibrium data.

$\text{Ni}^{++}(\text{aq.})$. This value is obtained from that for $\text{NiCl}_2(\text{aq.})$.

$\text{NiBr}_2(\text{aq.})$. From the values for the aqueous ions, we have computed, for $\text{NiBr}_2(\text{aq.})$, $Q_f = 72.4$. Fabre¹ reported the value 72.4.

$\text{NiBr}_2(\text{c})$. Crut¹ measured the heat of solution. See also his equilibrium data.

$\text{NiBr}_2 \cdot 3\text{H}_2\text{O}(\text{c})$. Crut¹ measured the heat of solution.

$\text{NiI}_2(\text{aq.})$. This value is obtained from the ions.

$\text{NiI}_2(\text{c})$. Mosnier¹ measured the heat of solution.

$\text{NiS}(\text{c})$. Thomsen¹⁵ measured the heat of reaction of $\text{NiSO}_4(400)$ with $\text{Na}_2\text{S}(400)$ to be 15.08.

$\text{NiSO}_4(\text{aq.})$. Thomsen¹⁵ measured the heat of the reaction of $\text{NiCl}_2(200)$ with $\text{H}_2\text{SO}_4(200)$, and of $\text{NiSO}_4(200)$ with $2\text{HCl}(100)$, to be 1.13 and 3.19, respectively; whence, for $\text{NiSO}_4(200)$, $Q_f = 231.1$.

$\text{NiSO}_4(\text{c})$. We have estimated the heat of solution of this substance.

$\text{NiSO}_4 \cdot 7\text{H}_2\text{O}(\text{c})$. Thomsen¹⁵ measured the heat of solution. See also Lescoeur.⁸

$\text{NiS}_2\text{O}_6(\text{aq.})$. The value for this substance is obtained from those for the ions.

$\text{NiS}_2\text{O}_6 \cdot 6\text{H}_2\text{O}(\text{c})$. Thomsen¹⁵ measured the heat of solution.

$\text{NiSe}(\text{c})$. Fabre¹ measured the heat of reaction of $\text{NiSe}(\text{c})$ with bromine water, and of $\text{NiSO}_4(\text{aq.})$ with $\text{Na}_2\text{Se}(\text{aq.})$, to be 101.2 and 35.7, respectively; whence, for $\text{NiSe}(\text{c})$, $Q_f = 12$ and 14.

$\text{NiTe}(\text{c})$. Fabre³ measured the heat of reaction of $\text{NiTe}(\text{c})$ with bromine water to be 115.5.

$\text{NiN}_6 \cdot \text{H}_2\text{O}(\text{c})$. Wohler and Martin¹ measured the heat of decomposition of this substance to be 89.5, the products being solid nickel, gaseous nitrogen, and gaseous water.

$\text{Ni}(\text{NO}_3)_2(\text{aq.})$. This value is obtained from those for the ions.

$\text{Ni}(\text{NO}_3)_2(\text{c})$. Guntz and Martin¹ measured the heat of solution.

$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}(\text{c})$. Thomsen¹⁵ measured the heat of solution.

Ni(NO₃)₂ · 6 H₂O (liq.). Reisenfeld and Milchsach¹ determined the heat of fusion of the hexahydrate to be -10.6 at 60° .

NiX₂ · n NH₃ (c). Ephraim^{1, 2, 8, 9} and Ephraim and Jahnsen¹ obtained dissociation pressure data on the hexammines of NiCl₂, NiBr₂, and NiI₂. Biltz and Fetkenheuer,^{1, 2} Biltz,^{4, 9} and Biltz and Hüttig² obtained dissociation pressure data on the mono-, di-, and hexammines of NiCl₂ and NiBr₂ and on the di- and hexammines of NiI₂, and measured the following heats of solution: NiCl₂ · 6 NH₃ (c), 44.3 in HCl (aq.), 9.8 in NH₃ (aq.); NiCl₂ · 2 NH₃ (c), 19.5 in HCl (aq.), 13.9 in NH₃ (aq.); NiCl₂ · NH₃ (c), 17.8 in HCl (aq.), 24.3 in NH₃ (aq.); NiCl₂ (c), 18.7 in HCl (aq.).

Ni(NO₂)₂ · 5 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(NO₃)₂ · 6 NH₃ (c). Ephraim² measured the dissociation pressures.

NiF₂ · H₂O · nNH₃ (c). Biltz and Rahlfs² obtained dissociation pressure data on the penta- and monoammines.

Ni(ClO₃)₂ · 6 NH₃ (c). Ephraim² and Ephraim and Jahnsen¹ measured the dissociation pressures.

Ni(ClO₄)₂ · 6 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(IO₃)₂ · 5 NH₃ (c). Ephraim and Jahnsen¹ measured the dissociation pressures.

NiSO₄ · nNH₃ (c). Ephraim^{2, 8} obtained dissociation pressure data on the ammines with $\frac{1}{2}$, 2, 4, and 6 NH₃.

NiSi₂O₆ · nNH₃ (c). Ephraim² measured the dissociation pressures of the penta- and hexammines.

NiSi₄O₆ · 6 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(H₂PO₂)₂ · 6 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(COOH)₂ · 4 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(C₂H₃O₂)₂ · 4 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(CNS)₂ · 6 NH₃ (c). Ephraim² measured the dissociation pressures.

Ni(NH₄)₂(SO₄)₂ · 6 H₂O (c). Caven and Ferguson² measured the dissociation pressures of the system, hexahydrate-dihydrate-water vapor.

NiC₃ (c). Roth's⁵ data on the heat of combustion of nickel carbide yield $Q_f = -9.2$. See also Ruff and Gersten.²

Ni(CO)₄ (liq.). From his vapor pressure data, Anderson² calculated the heat of vaporization.

Ni(CN)₂ (c, ppt.). Varet^{4, 5} measured the heats of the reactions of NiSO₄ (aq.) with 2 KCN (aq.), NiSO₄ (aq.) with 2 NaCN (aq.), Ni(NO₃)₂ (aq.) with 2 KCN (aq.), and Ni(NO₃)₂ (aq.) with 2 NaCN (aq.) to be 31.6 , 31.4 , 31.0 , and 30.9 , respectively.

Ni (CN)₄⁻ (aq.). Varet^{4, 5} measured the heat of solution of Ni (CN)₂ (c) in 2 KCN (aq.), 2 NaCN (aq.), Ba (CN)₂ (aq.), and Sr (CN)₂ (aq.), respectively.

Ni (C₂H₃O₂)₂ (aq.). This value is obtained from those for the ions.

NiBr₂ · 3 CH₃OH (c). Lloyd, Brown, Bonnell, and Jones¹ measured the dissociation pressures.

2 NiI₂ · PbI₂ (c). Mosnier¹ measured the heat of solution.

2 NiI₂ · PbI₂ · 3 H₂O (c). Mosnier¹ measured the heat of solution.

NiBr₂ · *n* HgBr₂ (aq.). Varet⁶ measured the heats of mixing NiBr₂ (aq.) with 1 and 2 moles of HgBr₂ (aq.).

(Ni + *n* Cu) (solid solution). White² measured the heat of fusion of monel metal, a solid solution of nickel and copper.

COBALT

Co (c, III). Standard state.

Co (c, II). For the heat of transition at the Curie point, 460°, Umino^{1a, 4} reported the values -0.13 and -0.06.

Co (c, I). For the heat of transition at 1150°, Umino^{1a, 4} reported the values -0.07 and -0.12. See also Wust, Meuthen, and Durrer,¹ and Pionchon.²

Co (liq.). Umino⁴ reported a value for the heat of fusion of cobalt.

Co (g). Millar¹ calculated the heat of sublimation at 25° to be -85.0. We have estimated the value for 2375°. See also Ruff and Kerlig.¹ The energy states of gaseous monatomic cobalt have been evaluated from the data of Catalan³ and Findlay.¹

Co⁺⁺ (aq.). The value for this substance is obtained from that for CoCl₂ (aq.).

CoO (c). Mixer¹¹ determined the heat of combustion of cobalt to form CoO (c) to be 57.5. See also Dulong.² Mixer's¹¹ experiments with sodium peroxide probably lead to the formation of Na₂CoO₃, in which case his data yield, for CoO (amorp.), *Q*_f=51. The recent equilibrium data of Emmett and Schultz¹ on the reaction, CoO (c) + H₂ (g) = Co (c) + H₂O (g), yield, for CoO (c), *Q*_f=56.2. See also Glaser,³ Chaudron,¹ and Wohler and Balz.²

Co₃O₄ (c). Mixer's¹¹ data on the reaction of Co₃O₄ (c) with sodium peroxide yield, for Co₃O₄ (c), *Q*_f=196.6. Biltz⁸ computed *Q*_f=196.2 from the dissociation pressure data of Foote and Smith.¹ The agreement is probably fortuitous.

Co(OH)₂ (c). Thomsen¹⁵ measured the heats of reaction of CoSO₄ (400) with Ba(OH)₂(400) and with 2 NaOH(200) to be 12.23 and 5.89, respectively.

Co(OH)₃ (c). Thomsen¹⁵ measured the heat of the reaction, 2 CoCl₂ (aq.) + NaClO (aq.) + H₂O (liq.) + 4 NaOH (aq.) = 2 Co(OH)₃ (c) + 5 NaCl (aq.).

CoF₂ (aq.). Petersen³ measured the heat of mixing CoCl₂ (aq.) with 2 AgF (aq.) to be 31.97.

CoF₂ (liq.). The high temperature equilibrium data of Jellinek and Rudat¹ on the reaction, $\text{CoF}_2 (\text{liq.}) + \text{H}_2 (\text{g}) = \text{Co} (\text{c}) + 2 \text{HF} (\text{g})$, yield the value $Qf^{700} = 161$.

CoCl₂ (aq.). Thomsen¹⁵ measured the heat of solution of Co (c) in 2 HCl (aq.) to be 16.35.

CoCl₂ (c). Thomsen¹⁵ measured the heat of solution.

CoCl₂ · 2 H₂O (c). Sabatier² measured the heat of solution.

CoCl₂ · 6 H₂O (c). Thomsen¹⁵ measured the heat of solution. See also the equilibrium data of Biltz,⁶ Lescœur,^{2, 4} Crut,¹ Jellinek and Podjaski,¹ and Jellinek and Uloth.¹

CoBr₂ (aq.). This value is obtained from those for the ions. Fabre¹ measured the heat of the reaction of Co (c) with bromine water to be 37.0.

CoBr₂ (c). Crut¹ measured the heat of solution to be 18.4; whence, for CoBr₂ (c), $Qf = 54.6$. Crut's¹ data on the equilibrium, $\text{CoBr}_2 (\text{c}) + \text{H}_2 (\text{g}) = \text{Co} (\text{c}) + 2 \text{HBr} (\text{g})$, yield, for CoBr₂ (c), $Qf = 56.9$.

CoBr₂ · 6 H₂O (c). Crut¹ measured the heat of solution.

CoI₂ (aq.). This value is obtained from those for the ions. Pigeon¹ measured the heat of reaction of Co (c) with NaI₃ (aq.) to be 41.5.

CoI₂ (c). Mosnier¹ measured the heat of solution.

CoS (c, ppt.). Thomsen¹⁵ measured the heat of the reaction of CoSO₄ (400) with Na₂S (400) to be 16.30. See also Jellinek and Zakowsky.¹

Co₂S₃ (c). We have estimated this value.

CoSO₄ (aq.). Thomsen¹⁵ measured the heat of reaction of CoSO₄ (400) with BaCl₂ (400) to be 5.69; and of CoCl₂ (200) with H₂SO₄ (200) and CoSO₄ (200) with 2 HCl (100) to be 1.15 and 2.44. These data yield, for CoSO₄ (400), $Qf = 231.7$, and for CoSO₄ (200), $Qf = 231.6$.

CoSO₄ (c). We have estimated the heat of dehydration of the hexahydrate and the heat of dissociation of the diammine.

CoSO₄ · 6 H₂O (c). Carpenter and Jette¹ measured the vapor pressures in the system, heptahydrate-hexahydrate-water vapor.

CoSO₄ · 7 H₂O (c). Thomsen¹⁵ measured the heat of solution.

CoSe (c). Fabre¹ measured the heat of reaction of CoSe (c) with bromine water to be 74.0 and of CoSO₄ (aq.) with Na₂Se (aq.) to be 33.1; whence, for CoSe (c), $Qf = 13.3$ and 12.0, respectively.

CoTe (c). Fabre¹ measured the heat of reaction of CoTe (c) with bromine water to be 115.9.

Co(NO₃)₂ (aq.). The value for this substance is obtained from those for the ions.

Co(NO₃)₂ (c). Guntz and Martin¹ measured the heat of solution.

Co(NO₃)₂ · 6 H₂O (c). Thomsen¹⁵ measured the heat of solution.

Co(NO₃)₂ · 6 H₂O (liq.). Reisenfeld and Milchsack¹ reported the heat of fusion to be -8.7 at 56° .

CoX₂ · nNH₃ (c). Biltz and Hüttig^{1, 2} and Biltz and Fetkenheuer² obtained dissociation pressure data on the ammines of CoCl₂ and CoBr₂ with 1, 2, and 6 NH₃, and those of CoI₂ with 2 and 6 NH₃, and measured

the following heats of solution in aqueous HCl: $\text{CoCl}_2 \cdot 6 \text{NH}_3$ (c), 46.3; $\text{CoCl}_2 \cdot 2 \text{NH}_3$ (c), 19.6; $\text{CoCl}_2 \cdot \text{NH}_3$ (c), 17.5; CoCl_2 (c), 18.0. Ephraim^{1, 9} measured the dissociation pressures of the hexammines of CoCl_2 , CoBr_2 , and CoI_2 .

$\text{CoF}_2 \cdot \text{H}_2\text{O} \cdot n\text{NH}_3$ (c). Biltz and Rahlfs² obtained dissociation pressure data on the ammines with $\frac{1}{2}$, 1, and 5 NH_3 .

$\text{CoSO}_4 \cdot n\text{NH}_3$ (c). Ephraim⁸ obtained dissociation pressure data on the ammines with $\frac{1}{2}$, 2, 3, 4, and 6 NH_3 .

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{NO}_3] (\text{NO}_3)_2$ (c). Lamb and Simmons¹ measured the heat of reaction of this substance with aqueous sodium sulfide, the cobalt product being Co_2S_3 (c).

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{NO}_3] (\text{NO}_3)_2$ (aq.). Lamb and Simmons¹ measured the heat of solution of the solid.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{NO}_3]^{++}$ (aq.). This value is obtained from the aqueous nitrate.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{H}_2\text{O}] (\text{NO}_3)_3$ (c). Lamb and Simmons¹ measured the heat of reaction of this substance with aqueous sodium sulfide, the product containing cobalt being Co_2S_3 (c).

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{H}_2\text{O}] (\text{NO}_3)_3$ (aq.). Lamb and Simmons¹ measured the heat of solution of the solid.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{H}_2\text{O}]^{+++}$ (aq.). This value is obtained from those for the aqueous nitrate, chloride, and bromide.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{H}_2\text{O}] \text{X}_3$ (c). Lamb and Simmons¹ measured the heats of reaction of the chloride and the bromide with aqueous sodium sulfide, the cobalt product being Co_2S_3 (c).

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{H}_2\text{O}] \text{X}_3$ (aq.). Lamb and Simmons¹ measured the heats of solution of the solid bromide and chloride.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{X}] \text{X}_2$ (c). Lamb and Simmons¹ measured the heats of reaction of the chloride and the bromide with aqueous sodium sulfide, the cobalt product being Co_2S_3 (c).

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{X}] \text{X}_2$ (aq.). Lamb and Simmons¹ measured the heats of solution of the solid chloride and the bromide.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{Cl}]^{++}$ (aq.). This value is obtained from the aqueous chloride.

$[\text{Co} \cdot (\text{NH}_3)_5 \cdot \text{Br}]^{++}$ (aq.). This value is obtained from the aqueous bromide.

$\text{CoBr}_2 \cdot 2 \text{NH}_4 \text{Br}$ (aq.). Varet⁶ measured the heat of mixing CoBr_2 (aq.) with $2 \text{NH}_4\text{Br}$ (aq.) to be 0.17.

$\text{Co} (\text{NH}_4)_2 (\text{SO}_4)_2 \cdot 6 \text{H}_2\text{O}$ (c). From dissociation pressure data, Caven and Ferguson¹ determined the heat of dissociation of the hexahydrate to the dihydrate.

Co_3C (c). The equilibrium data of Schenck, Krageloh, and Eisenstecken¹ yield $Q_f = -11.3$.

CoCO_3 (c). de Carli¹ measured the heat of the reaction of CoSO_4 (600) with Na_2CO_3 (600) to be -4.04 .

$\text{CoX}_2 \cdot n \text{CH}_3\text{OH}$ (c). Dissociation pressure data on $\text{CoCl}_2 \cdot 3 \text{CH}_3\text{OH}$

(c), $\text{CoBr}_2 \cdot 3 \text{CH}_3\text{OH}$ (c), and $\text{CoBr}_2 \cdot 2 \text{CH}_3\text{OH}$ (c) were obtained by Lloyd, Brown, Bonnell, and Jones.¹

$\text{Co}(\text{C}_2\text{H}_5\text{SO}_4)_2$ (aq.). Thomsen¹⁵ measured the heat of reaction of aqueous cobalt sulfate with aqueous barium ethyl sulfate to be 5.76.

$2 \text{CoI}_2 \cdot \text{PbI}_2$ (c). Mosnier¹ measured the heat of solution.

$2 \text{CoI}_2 \cdot \text{PbI}_2 \cdot 3 \text{H}_2\text{O}$ (c). Mosnier¹ measured the heat of solution.

$\text{CoBr}_2 \cdot n \text{HgBr}_2$ (aq.). Varet⁶ measured the heat of mixing CoBr_2 (aq.) with $\frac{1}{2}$, 1, and 2 moles of HgBr_2 (aq.).

$\text{CoCl}_3 \cdot 6\text{NH}_3$ (c). Biltz³ measured the dissociation pressures.

IRON

Fe (c). Normal iron at room temperature is taken as the standard state, and is labeled the α or IV form. The transition from IV to III, or α to β , is associated with a change in magnetic properties and takes place in the range from 725° to 785°, mainly at the Curie point, 769°. The data on this heat of transition are: Wust, Meuthen, and Durrer^{1, 2} -0.348; Pionchon,² -0.298; Osmond,¹ -0.07; Laschtschenko,² -0.30; Durrer,¹ -0.28 and -0.31; Stansfield,¹ -0.05; Meuthen,¹ -0.31; Klinkhardt,¹ -0.375; Bredemeier,¹ -0.737; Oberhoffer and Grosse,¹ -0.14. See also Dinkler¹ and Weiss, Piccard, and Carard.¹ The transition from III to II, or β to γ , occurs at 906°, and is associated with a change in crystal properties, the forms being martensite and ferrite. The data on the heat of this transition are: Klinkhardt,¹ -0.214; Durrer,¹ -0.37; Meuthen,¹ -0.30; Stansfield,¹ -0.159; Laschtschenko,¹ -0.34; Osmond,¹ -0.21; Wust, Meuthen, and Durrer,^{1, 2} -0.35; Oberhoffer and Grosse,¹ -0.38. For the heat of the transition from II to I, or γ to δ , which occurs at 1405°, the data are: Wust, Meuthen, and Durrer,^{1, 2} -0.103; Bredemeier,¹ -0.108; Durrer,¹ -0.108. See also the review of Yap.¹

Fe (liq.). The data on the heat of fusion of iron at its melting point, 1535°, are Umino,³ -3.86; Oberhoffer and Grosse,¹ -3.60.

Fe (g). The vapor pressure data of Greenwood^{3, 5} and Ruff and Bormann¹ were reviewed by Johnston, Fenwick, and Leopold¹ and yield -73.8 for the heat of vaporization at 2000°; whence at 18° the heat of sublimation becomes -89.0. For this latter Sherman¹ calculated -94, and Jones, Langmuir, and Mackay¹ reported -89. See also Millar.¹

The energy states of gaseous monatomic iron have been evaluated from the data of Laporte,¹ Russell,^{1, 2} White,⁵ and Gilroy.¹

Fe_3O_4 (c). The product of the combustion of iron in oxygen is principally Fe_3O_4 . The data on the heat of combustion of iron are: Dulong,² 278; Andrews,¹⁴ 275; Mixter,¹⁵ 265.2; Ruff and Gersten,³ 268.3; Ruff and Gersten,² 266.4; Baykoff and Erniloff,¹ 275; Roth,⁵ 266.9. See also Doepke.¹ Mixter's¹⁵ data on the reaction with sodium peroxide yield, for Fe_3O_4 (c, III), $Q_f=265$. Berthelot's⁷⁰ data on the heat of solution of iron in aqueous HCl yield $Q_f=289$. The heats of transition of Fe_3O_4 (c) were measured by Millar.⁶

FeO (c). The values for the heat of combustion of FeO (c) to form

$\frac{1}{3}$ Fe_3O_4 (c) are: LeChatelier,⁸ 25.2; Roth,⁵ 24.7. See also Ruff and Gersten,² Roth's⁵ value yields, for FeO (c, I), $Q_f=64.3$. Mixer's¹⁵ data on the reaction with sodium peroxide yield $Q_f=65.0$. The equilibrium data of Wohler and Gunther,¹ Chaudron,¹ and Groningen¹ on the reaction, Fe (c) + H_2O (g) = FeO (c) + H_2 (g), yield, for FeO (c, I) $Q_f=62.7$. See also Tigerschoild,¹ Schreiner and Grimmes,¹ Wohler and Balz,² von Royen,¹ Treadwell,¹ and Eastman and Evans.¹ The equilibrium data of Wohler and Gunther,¹ Chaudron,¹ and Groningen¹ on the reaction, 3FeO (c) + H_2O (g) = Fe_3O_4 (c) + H_2 (g), yield, for FeO (c, I), $Q_f=64.3$. From equilibrium data on the reaction, FeO (c) + CO (g) = Fe (c) + CO_2 (g), Garrañ calculated, for FeO (c, I), $Q_f=64.6$. See also Tigerschoild,¹ Matsubara,¹ and Chaudron.^{1, 2, 3} Millar⁶ measured the heat of transition.

Fe_2O_3 (c). For the heat of combustion of Fe_2O_3 (c) to form $\frac{2}{3}$ Fe_3O_4 (c), LeChatelier,^{8, 10} found -15 and Roth⁵ -20.6. The latter value yields, for Fe_2O_3 (c), $Q_f=198.5$. Mixer's¹⁵ data on the reaction with sodium peroxide yield 194.6. Berthelot⁷⁰ measured the heat of solution of iron in HCl (4) to be 17.1. See also Walden,¹ Biltz,⁸ Sosman and Hostetter,¹ and Treadwell.¹

$\text{Fe}(\text{OH})_2$ (c, ppt.). Thomsen¹⁵ measured the heats of the reactions of FeSO_4 (aq.) with 2KOH (aq.) and with $\text{Ba}(\text{OH})_2$ (aq.) to be 6.34 and 12.00, respectively; whence, for $\text{Fe}(\text{OH})_2$ (c, ppt.), $Q_f=135.9$.

$\text{Fe}(\text{OH})_3$ (c, ppt.). Thomsen¹⁵ measured the heat of the reaction of FeCl_3 (aq.) with 3NaOH (aq.) to be 24.5. See also Petersen³ and Mixer.¹⁵

Fe^{++} (aq.). The value for aqueous ferrous ion is obtained from that for aqueous ferrous chloride.

FeCl_2 (aq.). Thomsen¹⁵ and Richards, Rowe, and Burgess¹ measured the heat of solution of iron in 2HCl (200). Their data yield, for FeCl_2 (400), $Q_f=100.18$ and 99.76, respectively. See also Favre and Silbermann³ and Andrews.³

FeCl_2 (c). Thomsen¹⁵ found $S=17.90_{400}$. See also Favre and Silbermann.³

$\text{FeCl}_2 \cdot n\text{H}_2\text{O}$ (c). Sabatier^{2, 4} measured the heats of solution of the di- and tetrahydrates. Dissociation pressure data on the dihydrate were reported by Lescoeur.⁷

FeCl_2 (g). Maier's¹ vapor pressure data yield -32.1 for the heat of vaporization.

FeCl_3 (aq.). Thomsen¹⁵ measured the heats of reaction of FeCl_2 (aq.) with HClO (aq.) and with Cl_2 (g) to form FeCl_3 (aq.) to be 54.44 and 55.00, respectively. See also Berthelot,²⁶ Doerincel,¹ and Browne.¹ Data on the heat of dilution of aqueous ferric chloride were reported by Thomsen.¹⁵ (The heat of mixing aqueous ferric chloride with aqueous HCl is large.)

Fe^{+++} (aq.). Pissarjewsky^{1a} obtained data on the equilibrium, Fe^{++} (aq.) + Ag^+ (aq.) = Fe^{+++} (aq.) + Ag (c), and reported $Q=8.7$, whence,

for $\text{Fe}^{+++}(\text{aq.})$, $Qf=4.1$. Fleharty's¹ recent data on the equilibrium, $\text{Fe}^{++}(\text{aq.}) + \frac{1}{2} \text{Hg}_2^{++}(\text{aq.}) = \text{Fe}^{+++}(\text{aq.}) + \text{Hg}(\text{liq.})$, yield $Q=10.0$; whence, for $\text{Fe}^{+++}(\text{aq.})$, $Qf=10.6$. From the values for $\text{FeCl}_3(\text{aq.})$ and $\text{Cl}^-(\text{aq.})$, one obtains, for $\text{Fe}^{+++}(\text{aq.})$, $Qf=9.3$.

$\text{FeCl}_3(\text{c.})$. Lemoine¹ measured the heat of solution.

$\text{FeCl}_3 \cdot n\text{H}_2\text{O}(\text{c.})$. Sabatier^{2, 4} measured the heat of solution of the hydrate with $2\frac{1}{2} \text{H}_2\text{O}$, and Lemoine¹ that of the hexahydrate.

$\text{Fe}_2\text{Cl}_6(\text{g.})$. Deville and Troost¹ have shown that the vapor of ferric chloride has the formula Fe_2Cl_6 . The vapor pressure data of Stirnemann¹ yield -33.1 for the heat of sublimation of Fe_2Cl_6 .

$\text{Fe}_2\text{Cl}_6(\text{liq.})$. The vapor pressure data of Stirnemann¹ yield -11.3 for the heat of vaporization of the liquid.

$\text{FeF}_2(\text{aq.})$. Petersen³ measured the heat of mixing $2\text{AgF}(300)$ with $\text{FeCl}_2(600)$ to be 31.76 .

$\text{FeF}_2(\text{liq.})$. The equilibrium data of Jellinek and Rudat¹ yield, for $\text{FeF}_2(\text{liq.})$, $Qf^{800}=158$.

$\text{FeF}_3(\text{aq.})$. Petersen³ measured the heat of mixing $\text{FeCl}_3(300)$ with $3\text{HF}(50)$ and $\text{FeF}_3(300)$ with $3\text{HCl}(50)$, the heat of the reaction of $3\text{AgF}(200)$ with $\text{FeCl}_3(600)$, and the heat of solution of $\text{Fe}(\text{OH})_3(\text{c.})$ in aqueous HF . His data yield, for $\text{FeF}_3(1200)$, $Qf=243.3$, and for $\text{FeF}_3(300)$, $Qf=242.5$.

$\text{FeF}_3(\text{liq.})$. The dissociation pressure data of Jellinek and Rudat¹ yield, for $\text{FeF}_3(\text{liq.})$, $Qf^{700}=233$.

$\text{FeOCl}(\text{c.})$. Stirnemann's¹ data on the equilibrium in the system, $\text{FeOCl}(\text{c.}) - \text{Fe}_2\text{O}_3(\text{c.}) - \text{Fe}_2\text{Cl}_6(\text{g.})$; yield for the reaction, $6\text{FeOCl}(\text{c.}) = \text{Fe}_2\text{Cl}_6(\text{g.}) + 2\text{Fe}_2\text{O}_3(\text{c.})$, $Q=-26.0$; whence, for $\text{FeOCl}(\text{c.})$, $Qf=97.1$.

$\text{Fe}(\text{ClO}_3)_3(\text{aq.})$. Thomsen¹⁵ measured the heat of reaction of aqueous barium chlorate with aqueous ferric sulfate.

$\text{FeBr}_2(\text{aq.})$. This value is obtained from the ions.

$\text{FeBr}_2(\text{c.})$. We have estimated the heat of solution.

$\text{FeBr}_3(\text{aq.})$. The values for the ions yield $Qf=95.2$. Fabre¹ reported the low value 88.6 , which may be attributed to incomplete reaction.

$\text{FeI}_2(\text{aq.})$. This value is obtained from the ions.

$\text{FeI}_2(\text{c.})$. Mosnier¹ measured the heat of solution. See also Andrews.³

$\text{FeI}_3(\text{aq.})$. This value is obtained from the ions.

$\text{FeS}(\text{c.})$. The data on the directly measured heat of formation are: Mullenhoff,¹ 25.0 ; Mannheimer,¹ 22.8 ; Parravano and Cesaris,¹ 23.07 . Mixer's¹⁵ data on the reaction with sodium peroxide yield $Qf=19$. Berthelot¹⁴ and Thomsen¹⁵ measured the heat of reaction of aqueous ferrous sulfate with aqueous sodium sulfide, the latter's data yielding, for $\text{FeS}(\text{c.})$, $Qf=23.4$. See also Jellinek and Zakowsky.¹

$\text{FeS}(\text{liq.})$. For the heat of fusion, at 195° , Bornemann¹ reported -0.28 and Bornemann and Hegstenberg¹ -0.5 .

$\text{FeS}_2(\text{c.})$. Mixer's¹⁵ data on the heats of the reactions of pyrite and of marcasite with sodium peroxide yield identical values for the two crystal forms of $\text{FeS}_2(\text{c.})$, namely $Qf=35.5$. The data of Cavazzi² on the

heat of combustion of FeS_2 (c) yield the approximate value 44. See also the equilibrium data and calculations of Rudder and Ferrer,¹ Halferdahl,¹ Allen and Lombard,¹ and Kamura.¹ We have selected the value from Mixer's¹⁵ data because of the difficulty of interpreting the equilibrium data in terms of a pure reaction.

FeSO_4 (aq.). Thomsen¹⁵ reported $Q=3.60$ for the reaction, $\text{FeCl}_2(200) + \text{H}_2\text{SO}_4(200) = \text{FeSO}_4(200) + 2\text{HCl}(100)$; whence, for $\text{FeSO}_4(200)$, $Q_f=235.94$. Data on the heat of dilution of aqueous ferrous sulfate were reported by Thomsen.¹⁵

FeSO_4 (c). deForcrand⁶⁴ measured the heat of solution. See also the equilibrium data of Keppeler and d'Ans¹ and Greulich.¹

$\text{FeSO}_4 \cdot \text{H}_2\text{O}$ (c). deForcrand⁶⁴ measured the heat of solution.

$\text{FeSO}_4 \cdot 4\text{H}_2\text{O}$ (c). deForcrand⁶⁴ measured the heat of solution.

$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$ (c). The data on the heat of solution are: Thomsen,¹⁵ -4.52_{400} ; deForcrand,⁶⁴ -4.32_{110} ¹⁴. Dissociation pressure data on the heptahydrate were obtained by Cohen and Visser,² Schumb,¹ Precht and Kraut,¹ and Wiedemann.¹

$\text{Fe}_2(\text{SO}_4)_3$ (aq.). Thomsen¹⁵ measured the heat of reaction of aqueous barium chloride with aqueous ferric sulfate to be 27.43 per mole of ferric sulfate. His data yield, for $\text{Fe}_2(\text{SO}_4)_3(400)$, $Q_f=653.0$. See also Berthelot,⁵⁰ Tamanaeff,¹ and Pissarjewsky.² Data on the heat of dilution of aqueous ferric sulfate were reported by Thomsen,¹⁵ Lemoine,¹ and Berthelot.^{5, 26}

$\text{Fe}(\text{HSO}_4)_3$ (600). Berthelot⁵ measured the heat of mixing $3\text{H}_2\text{SO}_4(200)$ with $\text{Fe}_2(\text{SO}_4)_3(600)$.

FeSe (c). Fabre¹ measured the heat of reaction of FeSe (c) with bromine water to be 117.4, and of FeSO_4 (aq.) with Na_2Se (aq.) to be 30.1. His data yield, for FeSe (c), $Q_f=14.0$ and 13.2.

FeTe (c). Fabre's¹ data on the heat of solution of ferrous telluride in bromine water yield, for FeTe (c), $Q_f=8$.

Fe_4N (c). The equilibrium data of Emmett, Hendricks, and Braunauer¹ on the reaction, $2\text{Fe}_4\text{N}(\text{c}) + 3\text{H}_2(\text{g}) = 3\text{Fe}(\text{c}) + 2\text{NH}_3(\text{g})$, yield $Q=24.1$ at 500° , whence, for Fe_4N (c), $Q_f=-1.1$. See also Fowler and Hartog.^{1, 1a}

$\text{Fe}(\text{NO}_3)_2$ (aq.). This value is obtained from the ions.

$\text{Fe}(\text{NO}_3)_3$ (aq.). Berthelot's⁵⁰ data on heats of mixing yield, for $\text{Fe}(\text{NO}_3)_3(800)$, $Q_f=156.3$, and for $\text{Fe}(\text{NO}_3)_3(200)$, $Q_f=157.4$. See also Noyes and Braun.¹

$\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$ (c). Berthelot⁹ measured the heat of solution.

FeNOSO_4 (aq.). Manchot² calculated the heat of solution of NO (g) in FeSO_4 (aq.) to be 11.9, from vapor pressure data. By direct measurement, Gay¹ (see Manchot²) found 10.14.

FeNO^{++} (aq.). This value is obtained from that for FeNOSO_4 (aq.).

$\text{Fe}(\text{NH}_4)_2\text{NO}(\text{SO}_4)_2$ (aq.). Manchot,² from vapor pressure data, computed the heat of solution of NO (g) in $\text{Fe}(\text{NH}_4)_2(\text{SO}_4)_2$ (aq.) to be 11.9. By direct measurement, Gay¹ (see Manchot²) found 10.4.

FeNOCl₂ (aq.). Gay¹ (see Manchot²) found the heat of solution of gaseous nitric oxide in aqueous ferrous chloride to be 10.7.

FeNH₄(SO₄)₂ (aq.). Berthelot⁵ measured the heat of mixing aqueous ferric sulfate with aqueous ammonium sulfate.

(NH₄)₂Fe(SO₄)₂ · 6H₂O (c). Graham² measured the heat of solution.

NH₄Fe(SO₄)₂ · 12H₂O (c). Berthelot¹⁵¹ measured the heat of solution. See also Ephraim and Wagner.¹

FeCl₂ · nNH₃ (c). Dissociation pressure data were obtained on the deca-, hexa-, di-, and monoammines by Biltz and Rahlfs,¹ on the hexamine by Ephraim,^{1, 9} and on the di- and monoammines by Biltz and Hüttig.¹ See also Girardet¹ and Ephraim and Millman.¹ The existing data were summarized by Biltz, Klatte, and Rahlfs.¹

FeBr₂ · nNH₃ (c). Biltz⁵ and Biltz and Hüttig² reported dissociation pressure data on the hexa-, di-, and monoammines. See also Ephraim.⁹

FeI₂ · nNH₃ (c). The dissociation pressure data of Biltz and Hüttig¹ on the di- and hexammines were recalculated by Biltz and Rahlfs.¹ See also Ephraim.⁹

FeSO₄ · nNH₃ (c). Ephraim⁸ measured the dissociation pressures of the mono-, di-, tri-, tetra-, and hexammines.

FeBr₃ · 6NH₃ (c). Ephraim and Millman¹ measured the dissociation pressures.

FeF₂ · H₂O · nNH₃ (c). Biltz and Rahlfs¹ measured the dissociation pressures of the hemi-, mono-, and pentammines.

Fe₃C (c). Data on the heat of combustion of iron carbide were reported by Ruff and Gersten,² Watase,^{2, 4} Bergkoff and Ermiloff,¹ Brody, Jennings, and Hayes,¹ Roth,⁵ and Yap and Liu.¹ These data were reviewed by Roth,⁵ who concluded that for the reaction, 3Fe (c) + C (β graphite) = Fe₃C (c), $Q = -5.4$; whence, for Fe₃C (c), $Q_f = -5.2$ (since the standard state here is C (diamond)). See also Troost and Hautefeuille,³ Campbell,^{1, 2, 3} Maxwell and Hayes,¹ Schenck, Semiller, and Falcke,¹ and Kawakami.¹

(Fe + nC) (solid solution). Yarroda, from indirect measurements, calculated the heat of solution of carbon in iron to be -13.5.

Fe(CO)₅ (liq.). Roth⁵ found the heat of combustion of liquid iron carbonyl in oxygen to be 371.4, the products being CO₂ (g) and Fe₃O₄ (c). This gives, for Fe(CO)₅ (liq.), $Q_f = 189.8$. Mittasch¹ found $Q = 57.1$ for the reaction, Fe (c, α) + 5CO (g) = Fe(CO)₅ (liq.), whence, for Fe(CO)₅ (liq.), $Q_f = 191.2$.

Fe(CO)₅ (g). For the heat of vaporization of iron carbonyl, Trautz and Badsteubner¹ found -9.38, Dewar and Jones -7.7. See also Eyber.¹

Fe(CO)₅ (c). Mittasch¹ found the heat of fusion to be -3.25 at about -20°.

FeCO₃ (c). Berthelot¹² measured the heat of reaction of FeSO₄ (aq.) with Na₂CO₃ (aq.) to be -3.7, and, assuming that the precipitate was ferrous carbonate, his data yield, for FeCO₃ (c), $Q_f = 180$. LeChâtelier,^{8, 10} reported the heat of combustion of ferrous carbonate to be zero;

Roth⁵ reported the value 10.64. Using Roth's data one calculates, for FeCO_3 (c), $Q_f = 172.8$.

$\text{Fe}_2(\text{C}_2\text{O}_4)_3$ (aq.). The data of Lemoine¹ on the heat of mixing aqueous ferric chloride with aqueous oxalic acid, and of aqueous ferric oxalate with aqueous hydrochloric acid, yield, for $\text{Fe}_2(\text{C}_2\text{O}_4)_3(100)$, $Q_f = 610.4$. Data on the heat of dilution of aqueous ferric oxalate were reported by Lemoine.¹

$\text{Fe}(\text{C}_2\text{H}_3\text{O}_2)_3$ (aq.). Thomsen¹⁵ measured the heat of reaction of aqueous ferric sulfate with aqueous barium acetate to be 20.21. Berthelot⁵ measured the heat of reaction of aqueous ferric acetate with aqueous potassium hydroxide, and the reciprocal heats of mixing involving Fe^{+++} , $\text{C}_2\text{H}_3\text{O}_2^-$, H^+ , and Cl^- . Data on the heat of dilution of aqueous ferric acetate were reported by Berthelot.⁵

$\text{H}_4\text{Fe}(\text{CN})_6$ (aq.). Berthelot²⁷ measured the heat of the reaction of 6HCN (aq.) with $\text{Fe}(\text{OH})_2$ (c) in alkaline solution to form $\text{H}_4\text{Fe}(\text{CN})_6$ (aq.), and his data yield, for the latter $Q_f = -122.3$.

$\text{H}_4\text{Fe}(\text{CN})_6$ (c). Chretien and Guinchant¹ measured the heat of solution.

$\text{H}_3\text{Fe}(\text{CN})_6^-$ (aq.), $\text{H}_2\text{Fe}(\text{CN})_6^{--}$ (aq.), $\text{HFe}(\text{CN})_6^{---}$ (aq.), $\text{Fe}(\text{CN})_6^{---}$ (aq.). The values for these substances are obtained from the respective aqueous potassium salts.

$\text{H}_3\text{Fe}(\text{CN})_6$ (aq.). Berthelot²⁷ measured the heat of oxidation of aqueous ferrocyanic acid with bromine and with chlorine, his data yielding, for the ferricyanic acid, $\text{H}_3\text{Fe}(\text{CN})_6$ (aq.), $Q_f = -148.1$ and -148.4 , respectively.

$\text{H}_2\text{Fe}(\text{CN})_6^-$ (aq.), $\text{HFe}(\text{CN})_6^{--}$ (aq.), $\text{Fe}(\text{CN})_6^{---}$ (aq.). The values for these ions are obtained from the respective aqueous potassium salts.

$\text{FeCO}(\text{CN})_5^{--}$ (aq.). This value is obtained from that for the aqueous potassium salt.

$\text{Fe}_4(\text{Fe}(\text{CN})_6)_3$ (c). Berthelot²⁷ measured the heat of reaction of aqueous ferrocyanic acid with ferric hydroxide to be 75.6, and the heat of reaction of aqueous KCN with aqueous ferrous and ferric sulfates to be 225.0; whence, for ferric ferrocyanide, $Q_f = -322.5$ and -312 .

$(\text{NH}_4)_4\text{Fe}(\text{CN})_6 \cdot 3 \text{H}_2\text{O}$ (c). Chretien and Guinchant¹ measured the heat of solution.

$(\text{NH}_4)_4\text{Fe}(\text{CN})_6$ (aq.). Chretien and Guinchant¹ measured the heat of neutralization.

$\text{Zn}_2\text{Fe}(\text{CN})_6$ (c). Joannis¹ measured the heat of reaction of $\text{Na}_4\text{Fe}(\text{CN})_6$ (aq.) with 2ZnSO_4 (aq.) to be 6.6 and that of $\text{K}_3\text{Fe}(\text{CN})_6$ (aq.) with 2ZnSO_4 (aq.) + HI (aq.) to be 21.2.

$\text{H}_3\text{FeCO}(\text{CN})_5 \cdot \text{H}_2\text{O}$ (c). Muller³ measured the heat of combustion.

$\text{H}_3\text{FeCO}(\text{CN})_5$ (aq.). Muller³ measured the heat of solution of the monohydrate.

Fe_3Si (c). Campbell⁸ measured the heat of solution of Fe_3Si (c) and of Si (c) in aqueous cupric chloride to be 87 and 107, respectively. See also Osmond² and Troost and Hautefeuille.²

FeSiO₃ (c). LeChatelier^{8, 10} and Wologdine¹ reported identical values, $Q = 5$, for the reaction, $\text{FeO (c)} + \text{SiO}_2 \text{ (c)} = \text{FeSiO}_3 \text{ (c)}$. Le Chatelier^{8, 10} also found $Q = -7.6$ for the reaction, $\text{FeCO}_3 \text{ (c)} + \text{SiO}_2 \text{ (c)} = \text{FeSiO}_3 \text{ (c)} + \text{CO}_2 \text{ (g)}$. These data yield, for $\text{FeSiO}_3 \text{ (c)}$, $Q_f = 272.6$ and 274.1 , respectively.

2 FeI₂ · PbI₂ (c). Mosnier¹ measured the heat of solution.

2 FeI₂ · PbI₂ · 3 H₂O (c). Mosnier¹ measured the heat of solution.

MANGANESE

Mn (c). The standard state is Mn (c, III). Umino¹ measured the heats of transition.

Mn (liq.). The data on the heat of fusion of manganese at its melting point, 1260° , are: Umino,¹ -3.56 ; Wust, Meuthen, and Durrer,¹ -2.0 .

Mn (g). Vapor pressure data were reported by Greenwood^{2, 5} and Ruff and Bormann.¹ These data yield -65 for the heat of vaporization at 1900° , or -75 for the heat of sublimation at 18° . Millar¹ calculated for the latter -58 .

The values of the energy states of gaseous monatomic manganese are from Catalan.² See also Bacher and Goudsmit.¹

Mn⁺⁺ (aq.). This value is obtained from that for $\text{MnCl}_2 \text{ (aq.)}$.

Mn⁺⁺⁺ (aq.). This value is obtained from that for $\text{MnBr}_3 \text{ (aq.)}$.

MnO (c). For the heat of formation of MnO (c) from solid manganese prepared from amalgam Guntz¹² reported 98.6 . LeChatelier¹⁰ and Roth⁵ measured the heat of combustion of MnO (c, I) in oxygen to form $\frac{1}{3} \text{Mn}_3\text{O}_4 \text{ (c)}$, and obtained identical values, $Q = 18.5$, though the recent work of Roth is undoubtedly more accurate. This value yields, for MnO (c, I), $Q_f = 96.5$. Millar³ measured the heat of transition.

Mn₃O₄ (c). The heat of combustion of 3 Mn (c, III) in oxygen to form $\text{Mn}_3\text{O}_4 \text{ (c)}$ was measured by LeChatelier,¹⁰ Ruff and Gersten,² and Roth⁵ to be 318 , 329.7 , and 345.0 , respectively.

Mn₂O₃ (c). From the equilibrium data of Meyer and Rötger¹ on the reaction, $6 \text{Mn}_2\text{O}_3 \text{ (c)} = 4 \text{Mn}_3\text{O}_4 \text{ (c)} + \text{O}_2 \text{ (g)}$, Biltz⁸ calculated $Q = -50.4$, whence, for $\text{Mn}_2\text{O}_3 \text{ (c)}$, $Q_f = 238.3$. Equilibrium data on the reaction, $4 \text{MnO}_2 \text{ (c, I)} = 2 \text{Mn}_2\text{O}_3 \text{ (c)} + \text{O}_2 \text{ (g)}$, were reported by Wohler and Balz,² Meyer and Rötger,¹ and Drucker and Huttner.¹ The latter investigators reported $Q = -26.0$, whence, taking the value 123 for $\text{MnO}_2 \text{ (c, I)}$, one obtains, for $\text{Mn}_2\text{O}_3 \text{ (c)}$, $Q_f = 233$.

MnO₂ (c, ppt.). Thomsen¹⁵ measured the heat of reaction of aqueous manganous sulfate with aqueous potassium permanganate, and the heat of reaction of $\text{MnO}_2 \text{ (c, ppt.)}$ with aqueous ferrous sulfate plus aqueous sulfuric acid. His data yield, for $\text{MnO}_2 \text{ (c, ppt.)}$, $Q_f = 115.2$ and 115.9 , respectively.

MnO₂ (c, I). The data of Mixer¹¹ on the reactions of Mn (c) and $\text{MnO}_2 \text{ (c, I)}$ with sodium peroxide, yield for $\text{MnO}_2 \text{ (c, I)}$, $Q_f = 121.2$. The equilibrium data of LeChatelier¹⁰ on the reaction, $3 \text{MnO}_2 \text{ (c, I)} = \text{Mn}_3\text{O}_4 \text{ (c)} + \text{O}_2 \text{ (g)}$, yield $Q = -48.0$; whence, for $\text{MnO}_2 \text{ (c, I)}$, $Q_f = 131$.

MnO₂ (c, II). Millar³ measured the heat of transition.

Mn(OH)₂ (c, ppt.). Thomsen¹⁵ measured the heat of the reactions of MnSO₄(400) with Ba(OH)₂(400) and with 2 KOH(200) to be 10.31 and 4.91, respectively; whence, for Mn(OH)₂ (c, ppt.), $Q_f = 163.42$ and 163.42 . Berthelot¹⁴ measured the heat of reaction of MnCl₂(400) with 2 NaOH(200) to be 3.78, whence, for Mn(OH)₂ (c, ppt.), $Q_f = 162.3$.

Mn(OH)₃ (c, ppt.). Petersen³ measured the heat of mixing 2 MnF₃(aq.) with 3 HF(aq.) and the heat of neutralization of (2MnF₃+3 HF)(aq.) with 9 NaOH(aq.) to be -0.01 and 94.82 , respectively; whence, for Mn(OH)₃ (c, ppt.), $Q_f = 221$.

MnO₄⁻ (aq.). This value is obtained from that for KMnO₄(aq.).

HMnO₄ (aq.). The heat of ionization of this acid is assumed to be zero.

MnF₂ (aq.). Petersen³ measured the heat of reaction of MnCl₂(aq.) with 2 AgF(aq.) to be 31.7 .

MnF₃ (aq.). This value is obtained from the ions.

MnF₃ · 3 HF (aq.). Petersen³ measured the heat of mixing MnF₃(aq.) with 3 HF(aq.) to be -0.01 .

MnCl₂ (aq.). Thomsen¹⁵ measured the heat of solution of solid manganese (0.994 Mn) in 2 HCl(50) to be 49.6 ; whence, for MnCl₂(100), $Q_f = 128.3$. We have estimated the heat of dilution.

MnCl₂ (c). Thomsen¹⁵ measured the heat of solution. See also the equilibrium data of Jellinek and Rudat³ and Jellinek and Uloth.¹

MnCl₂ · nH₂O (c). For the heat of solution of the dihydrate, Foote and Saxton¹ found 8.20_{300} and Sabatier² found 8.1 . Thomsen¹⁵ measured the heat of solution of the tetrahydrate.

H₂MnCl₆ (aq.). Berthelot⁶⁸ measured the heat of solution of Cl₂(g) in concentrated aqueous 2 HCl · MnCl₂ to be 9.2 .

MnBr₂ (aq.). This value is obtained from the ions.

MnBr₂ (c). We have estimated the heat of solution to be 15 .

MnBr₂ · nH₂O (c). Lescoeur⁷ obtained dissociation pressure data on the di- and tetrahydrates.

MnBr₃ (aq.). Fabre¹ measured the heat of solution of manganese in bromine water to be 109 .

MnI₂ (aq.). This value is obtained from the ions.

MnI₂ (c). Mosnier¹ measured the heat of solution.

MnI₂ · nH₂O (c). Lescoeur¹ obtained dissociation pressure data on the mono-, di-, tetra-, and hexahydrates.

MnS (c, ppt.). For the heat of the reaction of MnCl₂(400) with Na₂S(400), Berthelot¹⁴ found $Q = 6.4$ and Thomsen¹⁵ found $Q = 7.78$. The latter figure yields, for MnS (c, ppt.), $Q_f = 47.0$. See also Wologdine and Penkiewitsch¹ and Jellinek and Podjaski.¹

MnSO₄ (aq.). Thomsen¹⁵ measured the heats of reaction of MnCl₂(200) with H₂SO₄(200) and MnSO₄(200) with 2 HCl(100), and of MnSO₄(400) with BaCl₂(400). His data yield, for MnSO₄(400), $Q_f = 264.91$ and 265.15 . Thomsen¹⁵ measured the heat of dilution.

MnSO_4 (c). Thomsen¹⁵ measured the heat of solution.

$\text{MnSO}_4 \cdot n\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heats of solution of the mono- and pentahydrates. Dissociation pressure data on the heptahydrate were obtained by Bolte,¹ Schottky,¹ Hollmann,¹ Lescœur,⁴ Linebarger,¹ and Carpenter and Jette.¹

$\text{Mn}_2(\text{SO}_4)_3$ (aq.). This value is obtained from the ions.

$\text{Mn}_2(\text{SO}_4)_3$ (c). Beck¹ measured the heat of solution.

MnS_2O_6 (aq.). This value is obtained from the ions.

$\text{MnS}_2\text{O}_6 \cdot 6\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

MnSe (c). Fabre¹ measured the heat of solution of MnSe (c) in bromine water to be 125.6, and the heat of reaction of MnSO_4 (aq.) with Na_2Se (aq.) to be 14.2; whence, for MnSe (c), $Q_f = 34$ and 26.3, respectively.

MnN_6 (c). Wohler and Martin¹ measured the heat of decomposition of the azide to be 94.0.

Mn_5N_2 (c). Neumann, Kroger, and Kunz¹ measured the heat of solution of the nitride in aqueous (18 per cent) sulfuric acid to be 278.35, and Neumann, Kroger, and Hoebler¹ measured the direct heat of combination to be 57.2. The former data yield $Q_f = 56.0$. See also Valensi.¹

$\text{Mn}(\text{NO}_3)_2$ (aq.). Thomsen¹⁵ measured the heat of reaction of $\text{Mn}(\text{OH})_2$ (c) with HNO_3 (aq.) to be 22.90, whence, for $\text{Mn}(\text{NO}_3)_2(400)$, $Q_f = 147.8$.

$\text{Mn}(\text{NO}_3)_2$ (c). Guntz and Martin¹ measured the heat of solution.

$\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$ (liq.). Reisenfeld and Milchsack¹ measured the heat of fusion of the hexahydrate.

$\text{Mn}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ (liq.). We have estimated the heat of dilution from 3 to 6 H_2O .

$\text{Mn}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$ (c). Morgan and Owens¹ measured the heat of fusion.

$\text{MnF}_2 \cdot \text{H}_2\text{O} \cdot n\text{NH}_3$ (c). Biltz and Rahlfs² measured the dissociation pressures of the ammines with 1 and 5 NH_3 .

$\text{MnX}_2 \cdot n\text{NH}_3$ (c). Biltz and Hüttig¹ obtained dissociation pressure data on the mono-, di-, and hexammines of MnCl_2 and MnBr_2 , and on the di- and hexammines of MnI_2 . Ephraim^{1, 9} obtained similar data on the hexammines of MnCl_2 , MnBr_2 , and MnI_2 .

$\text{MnSO}_4 \cdot n\text{NH}_3$ (c). Ephraim⁸ reported meager data on the ammines with $\frac{1}{2}$, 1, 2, 5, and 6 NH_3 .

$\text{MnBr}_2 \cdot 2\text{NH}_4\text{Br}$ (aq.). Varet⁸ measured the heat of mixing MnBr_2 (200) with 2 NH_4Br (100) to be 0.08.

$\text{MnCl}_2 \cdot 2\text{NH}_4\text{Cl} \cdot 2\text{H}_2\text{O}$ (c). Foote and Saxton¹ measured the heat of solution.

$\text{MnSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot n\text{H}_2\text{O}$ (c). Graham² measured the heat of solution of the hexahydrate. Ephraim and Wagner¹ reported the heat of dissociation of the hexahydrate to the dihydrate to be -11.2 per mole of water vapor.

Mn₂(PO₄)₃ (c, ppt.). Joly³ and Berthelot¹⁰¹ obtained data on the heats of reaction of MnCl₂(aq.) with various aqueous sodium phosphates. Because their published papers lack the details with which to make a proper interpretation of their data, we have given only the value for crystalline precipitated manganic phosphate.

Mn₃C (c). The data on the heat of combustion of Mn₃C (c) in oxygen to form Mn₃O₄ (c) and CO₂ (g) are: Ruff and Gersten,² 409.8; LeChatelier,¹⁰ 411.2; Roth,⁵ 419.8. These data yield, for Mn₃C (c), $Q_f = 29.7$, 28.3, and 19.7. See also Troost and Hautefeuille.³

MnCO₃ (c, ppt.). Thomsen¹⁵ found $Q = -2.04$ for the reaction of MnSO₄(400) with Na₂CO₃(400); Berthelot¹² found $Q^{16} = -2.36$ for the reaction of MnCl₂(200) with Na₂CO₃(200). These data yield, for MnCO₃ (c, ppt.), $Q_f = 207.85$ and 207.67, respectively.

MnCO₃ (c). For the heat of combustion of MnCO₃ (c) in oxygen to form $\frac{1}{3}$ Mn₃O₄ (c) + CO₂ (g), the following values were reported: Wologdine,¹ -3.5; LeChatelier,¹⁰ -5.1; Roth,⁵ -9.8.

MnC₂O₄ (c). Smith and Topley¹ measured the heat of solution in HNO₃(9).

MnC₂O₄ · nH₂O (c). Smith and Topley¹ measured the heat of solution in HNO₃(9) of the di- and trihydrates. Berthelot⁹ measured the heat of reaction of MnCl₂(100) with K₂C₂O₄(100) to form the solid dihydrate to be 4.3.

Mn(CHO₂)₂ (aq.). Berthelot⁹ measured the heat of neutralization of aqueous formic acid with Mn(OH)₂ (c) to be 21.4.

Mn(CHO₂)₂ (c). Berthelot⁹ measured the heat of solution.

Mn(CHO₂)₂ · 2 H₂O (c). Berthelot⁹ measured the heat of solution.

Mn(C₂H₃O₂)₂ (aq.). Berthelot^{9, 131} measured the heat of neutralization of Mn(OH)₂ (c) with aqueous acetic acid to be 22.1.

Mn(C₂H₃O₂)₂ (c). Berthelot^{9, 131} measured the heat of solution.

Mn(C₂H₃O₂)₂ · 4 H₂O (c). Berthelot^{9, 131} measured the heat of solution.

MnSiO₃ (gls.). Mulert¹ measured the heat of solution of this substance in aqueous (20%) HF.

MnSiO₃ (c). Mulert¹ measured the heat of solution of this substance in aqueous (20%) HF. For the reaction, MnO (c) + SiO₂ (c, quartz) = MnSiO₃ (c), LeChatelier¹⁰ reported $Q = 2.7$. For the reaction, MnCO₃ (c) + SiO₂ (c, quartz) = MnSiO₃ (c) + CO₂ (g), Wologdine¹ and Wologdine and Penkiewitsch¹ reported $Q = 19.6$. These data yield, for MnSiO₃ (c), $Q_f = 301.3$, 302.5, and 307.3, respectively.

2MnI₂ · PbI₂ (c). Mosnier¹ measured the heat of solution.

2MnI₂ · PbI₂ · 3 H₂O (c). Mosnier¹ measured the heat of solution.

MnBr₂ · nHgBr₂ (aq.). Varet⁶ measured the heats of mixing MnBr₂ (aq.) with $\frac{1}{2}$, 1, and 2 moles of HgBr₂ (aq.).

CHROMIUM

Cr (c). Standard state. Laschtschenko¹ reported a transition at 480° with $T = -0.13$, but no other investigator has found such a transition.

Cr (liq.). The data on the heat of fusion at 1600° are: Umino,³ -3.65 ; Wust, Meuthen, and Durrer,¹ -1.66 .

Cr (g). Greenwood^{2, 5} reported the boiling point of chromium to be 2200°. We have estimated the heat of vaporization to be -76 at 2200°. The energy states of gaseous monatomic chromium have been evaluated from the data of Kiess,¹ Catalan and Sancho,¹ Russell,⁶ and White.^{3, 4, 5}

Cr₇H₂ (c). Sieverts and Gotta² reported the heat of dissociation of this hydride to be -3.7 .

CrO₃ (c). Mixer^{6, 16} measured the heat of reaction of CrO₃ (c) with Na₂O (c) to be 77.0, and of Cr (c) with Na₂O₂ (c) to be 158.8; whence, for CrO₃ (c), $Q_f = 141.1$. Combination of the heat of neutralization of CrO₃ (aq.) with 2 NaOH (aq.), and of the heats of solution of CrO₃ (c) and Na₂CrO₄ (c) with Mixer's^{6, 16} data on the reaction, $\text{Cr (c)} + 3 \text{Na}_2\text{O}_2 \text{ (c)} = \text{Na}_2\text{CrO}_4 \text{ (c)} + 2 \text{Na}_2\text{O (c)}$, $Q = 158.8$, yields, for CrO₃ (c), $Q_f = 137.5$. Roth and Becker¹ measured the heats of the reactions, $\text{Cr (c)} + \frac{3}{2} \text{O}_2 \text{ (g)} = \frac{1}{2} \text{Cr}_2\text{O}_3 \text{ (c)}$ and $\text{CrO}_3 \text{ (c)} = \frac{1}{2} \text{Cr}_2\text{O}_3 \text{ (c)} + \frac{3}{2} \text{O}_2 \text{ (g)}$, to be 144.4 and -3.5 , respectively; whence, for CrO₃ (c), $Q_f = 147.9$.

Cr₂O₃ (c). Mixer^{6, 16} measured the heats of the reactions, $\text{Cr}_2\text{O}_3 \text{ (c)} + 3 \text{Na}_2\text{O}_2 \text{ (c)} = 2 \text{Na}_2\text{CrO}_4 \text{ (c)} + \text{Na}_2\text{O (c)}$ and $2 \text{CrO}_3 \text{ (c)} + 2 \text{Na}_2\text{O (c)} = 2 \text{Na}_2\text{CrO}_4 \text{ (c)}$, to be 107.8 and 154.0, respectively; whence for the reaction, $\text{Cr}_2\text{O}_3 \text{ (c)} + 1\frac{1}{2} \text{O}_2 \text{ (g)} = 2 \text{CrO}_3 \text{ (c)}$, $Q = -13.0$, and, for Cr₂O₃ (c), $Q_f = 265.6$. Roth and Becker¹ measured the heat of combustion of chromium in oxygen to form Cr₂O₃ (c) to be 288.9.

CrO₃ (aq.). The data on the heat of solution of CrO₃ (c) are: Briechner and Prins,¹ 2.47₈₀; Morges,¹ 2.2; Sabatier,⁵ 1.9. Data on the heat of dilution of aqueous CrO₃ were reported by Briechner and Prins¹ and Morges.¹

CrO₄⁻ (aq.). The value for this ion is obtained from Na₂CrO₄ (aq.) and K₂CrO₄ (aq.).

CrO (g). Ghosh¹ computed the energy of dissociation of CrO (g) from spectroscopic data.

Cr₂O₇⁻ (aq.). This value is obtained from those for Na₂Cr₂O₇ (aq.) and K₂Cr₂O₇ (aq.).

[CrX_{3-n}]ⁿX_n (aq.). Trivalent chromium salts form several distinct kinds of solutions: the purple solution, which is supposed to contain $[\text{Cr} \cdot 6 \text{H}_2\text{O}] \text{X}_3$; the green solution, which is supposed to contain $[\text{Cr} \cdot 4 \text{H}_2\text{O} \cdot \text{X}_2] \text{X}$; and others of less importance for the present purpose. In writing the formulas of the aqueous ions and molecules, we have omitted the water molecules, so that for the above molecules are written $[\text{Cr}] \text{X}_3$ and $[\text{Cr} \cdot \text{X}_2] \text{X}$ and the positive ions $[\text{Cr}]^{+++}$ and $[\text{Cr} \cdot \text{X}_2]^+$. The number of molecules of H₂O necessary to make the coordination number of chromium have the value 6 have been omitted in writing the formulas

of the aqueous ions and the aqueous molecules and in computing the respective heats of formation. When dichromates are reduced in acid solution, the product is the green solution containing $[\text{Cr} \cdot \text{X}_2]\text{X}$. Thomsen¹⁵ found $Q=219.6$ for the reaction, $2\text{CrO}_3(\text{aq.}) + 6\text{HCl}(\text{aq.}) + 3(\text{SnCl}_2 + 2\text{HCl})(\text{aq.}) = 3(\text{SnCl}_4 + 2[\text{Cr} \cdot \text{Cl}_2]\text{Cl})(\text{aq.}) + 6\text{H}_2\text{O}(\text{liq.})$; whence, for $[\text{Cr} \cdot \text{Cl}_2]\text{Cl}(\text{aq.})$, $Q_f=166.5$. Berthelot⁹⁶ found $Q=153.8$ for the preferable reaction, $\text{K}_2\text{Cr}_2\text{O}_7(\text{aq.}) + 8\text{HCl}(\text{aq.}) + 6\text{HI}(\text{aq.}) = (2[\text{Cr} \cdot \text{Cl}_2]\text{Cl} + 6\text{HCl} + 3\text{KCl})(\text{aq.}) + 7\text{H}_2\text{O}(\text{liq.}) + 3\text{I}_2(\text{c.})$; whence, for $[\text{Cr} \cdot \text{Cl}_2]\text{Cl}(\text{aq.})$, $Q_f=173.6$. Neuman, Kroger, and Kunz¹ measured the heat of solution of chromium in $\text{HCl}(8)$ to be 50.6; whence, assuming the product to be $[\text{Cr} \cdot \text{Cl}_2]\text{Cl}(\text{aq.})$, one finds, for the latter, $Q_f=167.3$. Recoura³ measured the heat of reaction of $[\text{Cr}](\text{OH})_3(\text{c, ppt.})$ with $3\text{HCl}(\text{aq.})$ to form $[\text{Cr}]\text{Cl}_3(\text{aq., purple})$ to be 20.7. Bjerrum¹ computed the heat of the same reaction to be 21.2, from data on the hydrolysis constant. Recoura³ measured the heat of reaction of $3\text{NaOH}(\text{aq.})$ with $[\text{Cr}]\text{Br}_3(\text{aq.})$ and with $[\text{Cr} \cdot \text{Br}_2]\text{Br}(\text{aq.})$.

$[\text{Cr} \cdot 6\text{H}_2\text{O}]\text{Br}_3(\text{c, purple})$. Recoura³ measured the heat of solution.

$[\text{Cr} \cdot 4\text{H}_2\text{O} \cdot \text{Br}_2] \cdot 2\text{H}_2\text{O}(\text{c, green})$. Recoura³ measured the heat of solution.

$[\text{CrCl}_2]\text{Cl}(\text{c, rose})$. Recoura³ measured the heat of solution.

$[\text{Cr} \cdot 4\text{H}_2\text{O} \cdot \text{Cl}_2]\text{Cl}(\text{c, green})$. Higley¹ measured the heat of solution.

$[\text{Cr} \cdot 4\text{H}_2\text{O} \cdot \text{Cl}_2]\text{Cl} \cdot 2\text{H}_2\text{O}(\text{c, green})$. Recoura³ measured the heat of solution.

$[\text{Cr} \cdot 4\text{H}_2\text{O} \cdot \text{Cl}_2]\text{Cl} \cdot 6\text{H}_2\text{O}(\text{c, green})$. Higley¹ measured the heat of solution.

$[\text{Cr} \cdot 6\text{H}_2\text{O}]\text{Cl}_3(\text{c, purple})$. Recoura³ measured the heat of solution.

$[\text{Cr}]^{+++}(\text{aq., purple})$. This value is obtained from that for the aqueous chloride.

$[\text{Cr}]^{++}(\text{aq.})$. This value is obtained from that for $\text{CrCl}_2(\text{aq.})$.

$\text{Cr}_3\text{O}_{10}^{--}(\text{aq.})$. We have estimated the heat of the reaction, $\text{Cr}_2\text{O}_7^{--}(\text{aq.}) + \text{CrO}_3(\text{aq.}) = \text{Cr}_3\text{O}_{10}^{--}(\text{aq.})$.

$\text{H}_2\text{CrO}_4(\text{aq.})$. We have taken this as equivalent to $\text{CrO}_3(\text{aq.}) + \text{H}_2\text{O}(\text{liq.})$.

$[\text{Cr} \cdot \text{Cl}_2]^+(\text{aq.})$. This value is obtained from that for the aqueous chloride.

$[\text{Cr}](\text{OH})_3(\text{c, ppt.})$. Recoura³ measured the heat of reaction of $[\text{Cr} \cdot \text{Cl}_2]\text{Cl}(\text{aq.})$ with $3\text{NaOH}(\text{aq.})$

$[\text{Cr} \cdot (\text{OH})_2]\text{OH}(\text{c, ppt.})$. Recoura³ measured the heat of reaction of this substance with $3\text{HCl}(\text{aq.})$.

$[\text{Cr} \cdot \text{OH}](\text{OH})_2(\text{c, ppt.})$. Recoura³ measured the heat of reaction of this substance with $3\text{HCl}(\text{aq.})$.

$[\text{Cr} \cdot (\text{OH})_2]\text{Cl}(\text{aq.})$. From data on the hydrolysis constant, Bjerrum¹ computed the heat of the reaction of this substance with $\text{HCl}(\text{aq.})$ to be 8.1.

$[\text{Cr} \cdot \text{OH}]\text{Cl}_2$ (aq.). From data on the hydrolysis constant, Bjerrum¹ computed the heat of reaction of this substance with HCl (aq.) to be 9.6.

$[\text{Cr}(\text{OH})]^{++}$ (aq.). This value is obtained from that for the aqueous chloride.

CrCl_2 (aq.). Recoura³ measured the heat of the reaction, $2\text{CrCl}_2(\text{aq.}) + \frac{1}{2}\text{O}_2(\text{g}) + \text{H}_2\text{O}(\text{liq.}) = 2[\text{Cr} \cdot \text{OH}]\text{Cl}_2(\text{aq.})$, to be 30.4.

CrCl_2 (c). Recoura³ measured the heat of solution. See also Jellinek and Koop.¹

$\text{CrCl}_2 \cdot 4\text{H}_2\text{O}$ (c, dark green). Recoura³ measured the heat of solution.

$\text{CrCl}_2 \cdot 3\text{H}_2\text{O}$ (c, light green). Knight and Rich¹ studied the equilibrium between the tetra- and trihydrates.

CrI_2 (c). Recoura³ measured the heat of solution.

CrI_2 (aq.). This value is obtained from the ions.

$[\text{Cr}]\text{F}_3$ (aq.). Petersen³ measured the heat of reaction of $[\text{Cr}]\text{F}_3$ (aq.) with 3NaOH (aq.) to be 23.65.

$\text{H}_3[\text{Cr}]\text{F}_6$ (aq.). Petersen³ measured the heat of reaction of $[\text{Cr}]\text{F}_3$ (aq.) with 3HF (aq.).

CrF_3 (c). Jellinek and Rudat¹ studied the equilibrium, $2\text{CrF}_2(\text{c}) + \text{F}_2(\text{g}) = 2\text{CrF}_3(\text{c})$, finding $Q = 158.0$.

CrF_2 (c). Jellinek and Rudat,¹ from equilibrium data on the direct formation, $\text{Cr}(\text{c}) + \text{F}_2(\text{g}) = \text{CrF}_2(\text{c})$, computed $Q_f = 152$.

CrO_2Cl_2 (liq.). Berthelot^{53, 54, 93} measured the heat of solution. See also Moles and Gomez.¹

CrO_2Cl_2 (g). From data on the boiling point elevation, Beckmann⁴ computed the heat of vaporization.

$[\text{Cr}]_2(\text{SO}_4)_3$ (aq., purple). Thomsen¹⁵ measured the heat of neutralization of $[\text{Cr}](\text{OH})_3$ (c, ppt.) with H_2SO_4 (aq.) to be 49.3; whence, for $[\text{Cr}]_2(\text{SO}_4)_3$ (aq., purple), $Q_f = 772.2$. Colson² measured the heat of reaction of 3BaCl_2 (aq.) with $[\text{Cr}]_2(\text{SO}_4)_3$ (aq.) to be 19.95; whence, for $[\text{Cr}]_2(\text{SO}_4)_3$ (aq., purple), $Q_f = 772.3$.

$[\text{Cr}_2 \cdot (\text{SO}_4)_3]$ (aq., green). Colson² measured the heat of reaction of this solution with 6NaOH (aq.) to be 61.1; whence $Q_f = 757.4$. See also Recoura.²

$[\text{Cr}_2 \cdot (\text{SO}_4)_2]\text{SO}_4$ (aq., green). Colson² measured the heat of reaction of this substance with 6NaOH (aq.) to be 57.6; whence $Q_f = 760.9$. See also Recoura.²

$[\text{Cr}_2 \cdot \text{SO}_4](\text{SO}_4)_2$ (aq., green). Colson² measured the heat of reaction of this substance with 6NaOH (aq.) to be 50.7; whence, $Q_f = 767.8$. See also Recoura.²

$\text{Cr}_2(\text{SO}_4)_3$ (aq., "modified"). When heated, the purple aqueous chromic sulfate is hydrolyzed, and we have assumed that this "modified" solution is $([\text{Cr}_2 \cdot (\text{SO}_4)_2](\text{OH})_2 + \text{H}_2\text{SO}_4)$ (aq.). Colson² measured the heats of reaction of both hydrolyzed and normal solutions with 6NaOH (aq.) to obtain the difference in their heats of formation.

$\text{Cr}_2(\text{SO}_4)_3 \cdot 6\text{H}_2\text{O}$ (c, green). Colson² measured the heat of solution.

$[\text{Cr} \cdot 6\text{H}_2\text{O}]_2(\text{SO}_4)_3 \cdot n\text{H}_2\text{O}$ (c, purple). Senechal¹ and Recoura² measured the heats of solution of various hydrates. We have utilized Senechal's¹ data to distinguish the three hydrates with $n=2, 3$, and 5 .

CrN (c). Neuman, Kroger, and Hawbler¹ reported $Q_f=29.5$. See also Valenski.¹

$(\text{NH}_4)_2\text{CrO}_4$ (aq.). Morges¹ measured the heat of reaction of CrO_3 (500) with NH_4OH (100) to be 23.48. See also Berthelot.⁹⁵

$(\text{NH}_4)_2\text{CrO}_4$ (c). Sabatier⁵ measured the heat of solution.

$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ (aq.). Berthelot⁹⁵ measured the heat of reaction of $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ (aq.) with NH_4OH (aq.) and with 2KOH (aq.). See also Morges¹ and Moles and Gonzales.¹

$(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ (c). For the heat of solution, Moles and Gonzales¹ found -12.90_{540}^{16} and Berthelot⁹⁵ -12.4^{13} .

$\text{CrCl}_2 \cdot n\text{NH}_3$ (c). Ephraim and Millman¹ obtained dissociation pressure data on the di- and triammines.

Cr_3C_2 (c). Heusler¹ studied the equilibrium, $3\text{Cr}_2\text{O}_3$ (c) + 13C (c) = $2\text{Cr}_3\text{C}_2$ (c) + 9CO (g), and calculated $Q = -297$.

PbCrO_4 (c). Goldblum and Stoffella¹ measured the heat of reaction of aqueous potassium chromate with aqueous lead nitrate to be 10.6. For the heat of the reaction of aqueous lead chloride with aqueous potassium chromate, Roth, Schwartz, and Buchner¹ found $Q = 11.16$.

$2\text{CrI}_2 \cdot \text{PbI}_2$ (c). Mosnier¹ measured the heat of solution.

$2\text{CrI}_2 \cdot \text{PbI}_2 \cdot 3\text{H}_2\text{O}$ (c). Mosnier¹ measured the heat of solution.

MOLYBDENUM

Mo (c). Standard state.

Mo (g). Jones, Langmuir, and Mackay¹ reported values for the vapor pressure of solid molybdenum. The energy states of gaseous monatomic molybdenum are evaluated from the data of Catalan¹ and Meggers and Kiess.¹ See also Bacher and Goudsmit.¹

MoO_3 (c). For the heat of formation of this substance, Moose and Parr¹ found 176.5, which value was obtained by combustion of molybdenum in oxygen in a bomb. For the same quantity, Delepine² found 167. Mixer's¹⁰ data on the reaction of Mo (c) with $3\text{Na}_2\text{O}_2$ (c) and of MoO_3 (c) with Na_2O (c) yield $Q = 205.3$ and 81.9 , respectively; whence, for MoO_3 (c), $Q_f = 182.7$.

MoO_2 (c). Mixer¹⁰ measured the heat of reaction of MoO_2 (c) with Na_2O_2 (c) to be 101.2.

H_2MoO_4 (aq.). Pechard¹ measured the heat of reaction of Na_2MoO_4 (aq.) with H_2SO_4 (400) to be 6.9.

MoO_3 (aq.). This is taken as equivalent to H_2MoO_4 (aq.) - H_2O (liq.).

MoO_4 (aq.). Pissarjewsky^{2, 4} measured the heat of reaction of MoO_3 (aq.) with H_2O_2 (aq.) to be 8.1.

MoO_5 (aq.). Pissarjewsky^{2, 4} measured the heat of reaction of MoO_3 (aq.) with $2\text{H}_2\text{O}_2$ (aq.) to be 12.35.

$\text{MoO}_3 \cdot n\text{H}_2\text{O}$ (c) or $\text{H}_2\text{WO}_4 \cdot (n-1)\text{H}_2\text{O}$ (c). Hüttig and Kurre¹ obtained dissociation pressure data on the mono- and dihydrates of MoO_3 .

MoO_4^{--} (aq.). This value is obtained from that for Na_2MoO_4 (aq.).

MoF_6 (c), MoF_6 (liq.). Ruff and Ascher¹ measured the vapor pressures of the solid and liquid.

PbMoO_4 (c). Tammann and Westerhold¹ calculated the heat of dissociation of $\text{PbO} \cdot \text{MoO}_3$ (c).

CuMoO_4 (c). Tammann and Westerhold¹ calculated the heat of dissociation of $\text{CuO} \cdot \text{MoO}_3$ (c).

FeMoO_4 (c). Tammann and Westerhold¹ calculated the heat of dissociation of $\text{FeO} \cdot \text{MoO}_3$ (c).

$\text{Fe}_2(\text{MoO}_4)_3 \cdot x\text{H}_2\text{O}$ (c). Tammann and Westerhold¹ calculated the heat of dissociation of the hydrated $\text{Fe}_2\text{O}_3 \cdot 3\text{MoO}_3 \cdot x\text{H}_2\text{O}$ (c) where x is unknown.

TUNGSTEN

W (c). Standard state.

W (g). Values for the vapor pressure of solid tungsten were computed by Jones, Langmuir, and Mackay¹ from data on the rate of loss of weight of heated tungsten wires. See also van Liempt.² The values for the energy states of gaseous monatomic tungsten are from Bacher and Goudsmit.¹

WO_3 (c). For the heat of combustion of tungsten in oxygen to form WO_3 (c), Moose and Parr¹ found 195.7. See also Delepine and Hallopeau,¹ Delepine,⁶ Wiess, Martin, and Stimmelmayer,¹ and van Liempt.⁴ Mixer's⁶ data on the heat of the reaction of W (c) with $3\text{Na}_2\text{O}_2$ (c) and of WO_3 (c) with Na_2O (c) yield $Q = 231.2$ and 94.70 , respectively; whence, for WO_3 (c), $Q_f = 195.8$.

WO_2 (c). Delepine and Hallopeau¹ measured the heat of combustion of WO_2 (c) to form WO_3 (c) to be 65.2 ; whence, for WO_2 (c), $Q_f = 130.5$. From equilibrium studies, Shibata² calculated $Q = 11.5^{1000}$ for the reaction, $\frac{1}{2}\text{WO}_2$ (c) + CO (g) = $\frac{1}{2}\text{W}$ (c) + CO_2 (g), whence, for WO_2 (c), $Q_f = 115$. Similar data on the reaction, W (c) + $2\text{H}_2\text{O}$ (g) = WO_2 (c) + H_2 (g), which was studied by Chaudron,^{1,2} yield $Q = 8.8$, whence, for WO_2 (c), $Q_f = 124$.

W_2O_5 (c). Shibata² studied the equilibria, W_2O_5 (c) + CO (g) = 2WO_2 (c) + CO_2 (g) and 2WO_3 (c) + CO (g) = W_2O_5 (c) + CO_2 (g), and calculated $Q = 4.7$ and 7.2 , respectively; whence, for W_2O_5 (c), $Q_f = 324$ and 331 . Chaudron's¹ data on the equilibrium, 2WO_2 (c) + H_2O (g) = W_2O_5 (c) + H_2 (g), yield $Q = 4.0^{850}$; whence, for W_2O_5 (c), $Q_f = 323$. See also Alterthum and Koref¹ and van Liempt.³

H_2WO_4 (c), or $\text{WO}_3 \cdot \text{H}_2\text{O}$ (c). Hüttig and Kurre¹ obtained data on the dissociation pressure.

H_2WO_4 (aq.). Pissarjewsky² measured the heat of solution of the solid in aqueous NaOH to be 13.7 .

$\text{WO}_3 \cdot n\text{H}_2\text{O}_2$ (aq.). Pissarjewsky² measured the heat of mixing

H_2WO_4 (aq.) with 1, 2, and 3 moles of H_2O_2 (aq.) to be 0.9, 1.5 and 3.2, respectively.

WF_6 (c), WF_6 (liq.). Ruff and Ascher¹ measured the vapor pressures of the liquid and solid.

WS_2 (c). Parravano and Malquori² studied the equilibrium W (c) + $2\text{H}_2\text{S}$ (g) = WS_2 (c) + 2H_2 (g), and computed $Q = 73.4^{950}$.

$\text{W}(\text{CN})_8^{---}$ (aq.), $\text{W}(\text{CN})_8^{---}$ (aq.). Collenberg¹ reported $Q = 16.85$ for the reaction, Hg (liq.) + Cl^- (aq.) + $\text{W}(\text{CN})_8^{---}$ (aq.) = HgCl (c) + $\text{W}(\text{CN})_8^{---}$ (aq.).

CuWO_4 (c). Tammann and Westerhold¹ reported the heat of the reaction of CuO (c) with WO_3 (c) to be 12.1.

$\text{CuWO}_4 \cdot 2\text{H}_2\text{O}$ (c). Tammann and Westerhold¹ reported $Q = 19.0$ for the reaction of CuO (c) with WO_3 (c) and $2\text{H}_2\text{O}$ (liq.).

FeWO_4 (c). Tammann and Westerhold¹ reported $Q = 9.7$ for the reaction of FeO (c) with WO_3 (c).

$\text{FeWO}_4 \cdot 3\text{H}_2\text{O}$ (c). Tammann and Westerhold¹ reported $Q = 17.2$ for the reaction of FeO (c) with WO_3 (c) and $3\text{H}_2\text{O}$ (liq.).

$\text{Fe}_2(\text{WO}_4)_3 \cdot 8\text{H}_2\text{O}$ (c). Tammann and Westerhold¹ reported $Q = 7.2$ for the reaction of Fe_2O_3 (c) with 3WO_3 (c) and $8\text{H}_2\text{O}$ (liq.).

URANIUM

U (c). Standard state.

U (g). We have estimated the heat of sublimation.

UO_3 (c). Mixer¹⁴ measured the heats of the reactions, U (c) + $3\text{Na}_2\text{O}_2$ (c) = Na_2UO_4 (c) + $2\text{Na}_2\text{O}$ (c) and UO_3 (c) + Na_2O (c) = Na_2UO_4 (c), to be 341.8 and 96.1, respectively; whence, for UO_3 (c), $Q_f = 305.0$. Mixer¹⁴ measured the heats of the reactions, 3U (c) + 4O_2 (g) = U_3O_8 (c), U_3O_8 (c) + Na_2O_2 (c) + $2\text{Na}_2\text{O}$ (c) = $3\text{Na}_2\text{UO}_4$, and UO_3 (c) + Na_2O (c) = Na_2UO_4 (c), to be 845.2, 285.1, and 96.1, respectively; whence, for UO_3 (c), $Q_f = 287.3$. Biltz and Fendius¹ measured the heat of solution of UO_3 (c) in $(\text{FeCl}_3 + \text{HCl})$ (aq.) to be 20.8, and combining this with other unnamed data deduced, for UO_3 (c), $Q_f = 291.6$.

UO_2 (c). Mixer¹⁴ measured the heat of the reaction, UO_2 (c) + Na_2O_2 (c) = Na_2UO_4 (c), to be 110.9.

U_3O_8 (c). Mixer¹⁴ measured the heat of combustion of U (c) in oxygen to form U_3O_8 (c) to be 845.2, and measured the heat of the reaction, U_3O_8 (c) + Na_2O_2 (c) + $2\text{Na}_2\text{O}$ (c) = $3\text{Na}_2\text{UO}_4$ (c), to be 285.1. The latter reaction yields, for U_3O_8 (c), $Q_f = 857.8$.

$\text{UO}_3 \cdot n\text{H}_2\text{O}$ (c). Hüttig and Kurre,¹ from dissociation pressure data, computed the heats of dissociation of the hydrates with 2, $1\frac{1}{2}$, 1, and $\frac{1}{2}$ H_2O to be 15.0, 16.7, 20.2, and 26.6, respectively, per mole of H_2O (g). de Forcrand⁵⁸ measured the heats of solution of the anhydrous oxide and the mono- and dihydrates in 2HNO_3 (110) to be 19.8, 14.85, and 12.38, respectively. Aloy¹ measured the heat of solution of the dihydrate to be 8.8 in 2HBr (100), 8.4 in 2HNO_3 (100), 8.4 in 2HCl (100), 9.5 in H_2SO_4 (200), and 7.5 in $2\text{HC}_2\text{H}_3\text{O}_2$ (100).

UO_2Cl_2 (aq.). Aloy¹ measured the heat of solution of $\text{UO}_3 \cdot 2 \text{H}_2\text{O}$ (c) in 2HCl (100) to be 8.4.

$\text{UO}_2(\text{NO}_3)_2$ (aq.). de Forcrand⁵⁸ measured the heat of solution of UO_3 (c) in 2HNO_3 (110) to be 19.8.

UO_2SO_4 (aq.). Aloy¹ measured the heat of solution of $\text{UO}_3 \cdot 2 \text{H}_2\text{O}$ (c) in H_2SO_4 (200) to be 9.5.

UO_2Br_2 (aq.). Aloy¹ measured the heat of solution of $\text{UO}_3 \cdot 2 \text{H}_2\text{O}$ (c) in 2HBr (100) to be 8.8.

$\text{UO}_2(\text{C}_2\text{H}_3\text{O}_2)_2$ (aq.). Aloy¹ measured the heat of solution of $\text{UO}_3 \cdot 2 \text{H}_2\text{O}$ (c) in $2 \text{HC}_2\text{H}_3\text{O}_2$ (100) to be 7.5.

UO_2^{++} (aq.). This value is obtained from those for the aqueous chloride and nitrate.

$\text{UO}_2\text{Cl}_2 \cdot \text{H}_2\text{O}$ (c). Aloy¹ measured the heat of solution.

$\text{UO}_4 \cdot 2 \text{H}_2\text{O}$ (c). Pissarjewsky¹ measured the heats of solution of $\text{UO}_3 \cdot \text{H}_2\text{O}$ (c) and of $\text{UO}_4 \cdot 2 \text{H}_2\text{O}$ (c) in H_2SO_4 (55) to be 15.35 and -0.11 , respectively.

UF_6 (g). Ruff and Heinzelmänn¹ measured the vapor pressure of the liquid.

UCl_3 (c), UCl_4 (c). Biltz and Fendius¹ reported the heats of solution of U (c), UCl_4 (c), and UCl_3 (c) in HCl (8) to be 144.4, 39.4, and 40.6, respectively; the heats of solution of UO_3 (c), UCl_4 (c), and UCl_3 (c) in $(\text{FeCl}_3 + \text{HCl})$ (aq.) to be 20.8, 30.3, and 30.3, respectively; the heat of solution of Cl_2 (g) in $(\text{FeCl}_2 + \text{UCl}_3)$ (aq.) to be 42.8; the heat of solution of Cl_2 (g) in $(\text{ICl}_3 + \text{UCl}_4)$ (aq.) to be 13.5; and the heats of solution of UO_3 (c) and UCl_4 (c) in $(\text{ICl}_3 + \text{HCl})$ (aq.) to be 20.7 and 60.2, respectively.

$\text{U}(\text{SO}_4)_2$ (c). Beck¹ measured the heat of reaction with NaOH (aq.) to be 56.5.

UO_2SO_4 (c). Beck¹ measured the heat of reaction of this substance with KOH (aq.) to be 42.3.

$\text{UO}_2\text{SO}_4 \cdot 3 \text{H}_2\text{O}$ (c). Aloy¹ measured the heat of solution to be 5.1_{1000} . See also Favre and Silbermann.³

U_3N_4 (c). Neumann, Kroger, and Haebler¹ reported $Q_f = 274$.

$\text{UO}_2(\text{NO}_3)_2$ (c). The data on the heat of solution are: de Forcrand,⁵⁸ 19.0_{220}^{12} ; Marketos,¹ 16.0.

$\text{UO}_2(\text{NO}_3)_2 \cdot \text{H}_2\text{O}$ (c). de Forcrand⁵⁸ measured the heat of solution.

$\text{UO}_2(\text{NO}_3)_2 \cdot 2 \text{H}_2\text{O}$ (c). de Forcrand⁵⁸ measured the heat of solution.

$\text{UO}_2(\text{NO}_3)_2 \cdot 3 \text{H}_2\text{O}$ (c). The data on the heat of solution are: Aloy,¹ -3.7_{1000} ; de Coninck,¹ -3.8 ; de Forcrand,⁵⁸ 1.85_{220}^{12} .

$\text{UO}_2(\text{NO}_3)_2 \cdot 6 \text{H}_2\text{O}$ (c). The data on the heat of solution are: de Forcrand,⁵⁸ -5.45_{220}^{12} ; Marketos,¹ -4.0 .

UC_2 (c). From equilibrium data on the reaction, UO_2 (c) + 4C (c) = UC_2 (c) + 2CO (g), Heusler¹ calculated $Q = 174.6$.

$\text{UO}_2(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot 2 \text{H}_2\text{O}$ (c). Aloy¹ measured the heat of solution.

$\text{UO}_2\text{NH}_4(\text{C}_2\text{H}_3\text{O}_2)_3 \cdot 6 \text{H}_2\text{O}$ (c). Aloy¹ measured the heat of solution.

UO_2CrO_4 (aq.). This value is obtained from the ions.

$\text{UO}_2\text{CrO}_4 \cdot 5\frac{1}{2} \text{H}_2\text{O}$ (c). Aloy¹ measured the heat of solution.

VANADIUM

V (c). Standard state.

V (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic vanadium are from Bacher and Goudsmit¹ and White.^{3, 4}

V_2O_2 (c), V_2O_3 (c), V_2O_4 (c), V_2O_5 (c). Mixer¹⁴ measured the heat of combustion of vanadium* in oxygen, the product being a mixture of oxides: V (c) + 2.13 O_2 (g) = 0.74 V_2O_4 (c) + 0.26 V_2O_5 (c), $Q = 381$; V_2O_2 (c) + 1.2 O_2 (g) = 0.60 V_2O_4 (c) + 0.40 V_2O_5 (c), $Q = 208.0$; V_2O_3 (c) + 0.7 O_2 (g) = 0.60 V_2O_4 (c) + 0.40 V_2O_5 (c), $Q = 55.2$. Mixer¹⁴ also measured the heat of reaction of vanadium and the various oxides of vanadium with the sodium oxides, and his data yield the following values: V_2O_5 (c) + Na_2O (c) = $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_5$ (c), $Q = 165$; V_2O_4 (c) + Na_2O_2 (c) = $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_5$ (c), $Q = 174.6$; V_2O_3 (c) + 2 Na_2O_2 (c) = $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_5$ (c) + Na_2O (c), $Q = 214.8$; V_2O_2 (c) + 3 Na_2O_2 (c) = $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_5$ (c) + 2 Na_2O (c), $Q = 340.3$; 2 V (c) + 5 Na_2O_2 (c) = $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_5$ (c) + 4 Na_2O (c), $Q = 441$.

Ruff and Friedrich¹ measured the heat of combustion of pure vanadium in oxygen, to form a mixture whose composition was not determined, to be 304. Ruff and Friedrich¹ also measured the heats of reaction with the sodium oxides; and their data yield the following values: V_2O_3 (c) + O_2 (g) = V_2O_5 (c), $Q = 135$; V_2O_5 (c) + Na_2O (c) = $\text{Na}_2\text{O} \cdot \text{V}_2\text{O}_5$ (c), $Q = 20.0$ (this value is to be compared with the value obtained by Mixer¹⁴ which is undoubtedly too large). Muller⁵ studied the equilibrium, V_2O_5 (c) + H_2 (g) = V_2O_4 (c) + H_2O (g), and calculated $Q = 117$. Ruff and Martin¹ and Muthmann, Wiess, and Riedebeauch¹ measured the heat of combustion of vanadium (not very pure) in oxygen to form a mixture of oxides, whose composition was not determined, to be 250.5 and 313.0, respectively, per mole of vanadium.

The best correlation of all the foregoing data on the heats of the reactions involving the oxides of vanadium is obtained by selecting for V_2O_5 (c), $Q_f = 437$; whence we have obtained as best values for the other oxides, V_2O_4 (c), V_2O_3 (c), and V_2O_2 (c), 383, 330, and 195, respectively.

VO_3^- (aq.), VO_4^- (aq.), VO_5^- (aq). These values are obtained from those for NaVO_3 (aq.), KVO_3 (aq.), KVO_4 (aq.), and NaVO_5 (aq.).

NH_4VO_3 (c). Matignon¹² measured the heat of reaction of NH_4VO_3 (c) with NaOH (aq.) to be 12.30 at 15°.

VCl_4 (liq.). Ruff and Friedrich¹ measured the heat of solution of this substance in NaHO_2 (8) to be 161.8.

VCl_3 (liq.). Ruff and Friedrich¹ measured the heat of solution of the liquid trichloride in NaHO_2 (8) to be 19.6.

*The older investigators did not have pure vanadium to work with; Mixer's¹⁴ sample was 90% V, and those of Ruff and Martin¹ ranged from 84 to 97%.

VOCl₃ (c). Ruff and Friedrich¹ measured the heat of solution of this solid oxychloride in NaHO₂(8) to be 98.1.

VCl₂ (c). Ruff and Friedrich¹ measured the heat of combustion of this substance.

V₂F₃ (aq). Petersen³ measured the heat of reaction of V₂F₃ (aq.) with 1, 2, and 3 NaOH (aq.) to be 8.31, 16.09, and 15.13, respectively.

(NH₄)₃VF₃ (aq). Petersen³ found $Q = 22.42$ for the reaction of this substance with 3 NaOH (aq.).

V₂O₄ · H₂O (c). Gain¹ reported 12.62 and 10.89 for the heats of solution in 2 H₂SO₄(55) of V₂O₄ · H₂O (c, rose) and V₂O₄ · H₂O (c, green), respectively. The heat of reaction of the resulting solutions with aqueous potassium hydroxide was found by Gain¹ to be 16.92 and 18.56, respectively.

COLUMBIUM

Cb (c). Standard state.

Cb₂O₅ (c). Muthmann, Weiss, and Riedeabauch¹ measured the heat of combustion of columbium.

TANTALUM

Ta (c). Standard state.

Ta₂O₅ (c). The data of Moose and Parr¹ yield 499.6 for the heat of combustion of tantalum to form Ta₂O₅ (c); Muthmann, Weiss, and Riedeabauch¹ reported 308.

PROTOACTINIUM

Pa (c). Standard state.

TITANIUM

Ti (c). Standard state.

Ti (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic titanium are from Russell,⁴ Russell and Lang,¹ Harrison and Engwicht,¹ and Harrison.¹

TiO₂ (c, rutile III). Mixer's⁸ data on the reactions of Ti (c) with 3 Na₂O₂ (c) and of TiO₂ (c, rutile) with Na₂O₂ (c) yield $Q = 226$ and 50.3 , respectively; whence, for TiO₂ (c, rutile III), $Q_f = 216.1$. Mixer's¹³ data on the heat of combustion of titanium in oxygen yield $Q_f = 217.5$; those of Roth and Becker^{2, 3} yield $Q_f = 218.7$; and those of Sieverts and Gotta¹ yield $Q_f = 220.7$. See also Weiss and Kaiser.¹

TiO₂ (c, rutile II), TiO₂ (c, rutile I). Laschtschenko¹ reported values for the heats of transition of rutile.

TiO₂ (c, anatase). Laschtschenko¹ reported values for the heats of transition of anatase.

TiO₂ (amorphous). Mixer's^{8, 13} data yield a value for the difference in heat content of rutile and the amorphous form of TiO₂.

TiO₂ (hydrated ppt.). We have estimated this value.

TiCl₄ (aq). Thomsen¹⁵ measured the heat of reaction of this substance with 4 NaOH (aq.) to be 47.66.

TiCl₄ (liq.). Thomsen¹⁵ measured the heat of solution of the liquid to be 57.86₂₀₀₀; Bock and Moser¹ found 59.0.

TiCl₄ (c). Latimer¹ reported a value for the heat of fusion.

TiCl₄ (g). The vapor pressure data of Arie³ yield, for the heat of vaporization of the liquid, -8.62 at 136° and -8.97 at 18°.

TiCl₃ (c). Bock and Moser¹ reported the heats of solution of the brown and violet forms of this substance.

H₂TiF₆ (aq.). Thomsen¹⁵ measured the heat of reaction of TiO₂ (hydrated ppt.) with 6 HF (aq.) to be 30.9.

TiC (c). Brantley and Beckman¹ studied the equilibrium, TiO₂ (c) + 3 C (c) = TiC (c) + 2 CO (g), and computed $Q = -45.9$ at 1573°.

TiX₄ · nPH₃ (c). Holtje¹ reported the heats of the reactions, TiCl₄ (liq.) + PH₃ (g) = TiCl₄ · PH₃ (c) and TiCl₄ · PH₃ (c) + PH₃ (g) = TiCl₄ · 2 PH₃ (c), to be 18.6 and 10.8, respectively; and the heats of the analogous reactions with TiBr₄ to be 16.0 and 11.8, respectively.

TiX₄ · nH₂S (c). Biltz and Kennecke¹ obtained dissociation pressure data on the chloride and the bromide with 1 and 2 H₂S.

ZIRCONIUM

Zr (c). Standard state.

Zr (g). We have estimated the heat of sublimation. The values of the energy states of gaseous monatomic zirconium are from Kiess and Kiess.^{1, 2}

ZrO₂ (c, monoclinic). For the heat of combustion of zirconium, Roth and Becker¹ reported the value 263.4, but from later and presumably more accurate experiments Roth and Becker³ obtained the value 258.1. (The product formed in this last investigation was established to be the monoclinic form by X-ray studies.) For the same reaction, Sieverts, Gotta, and Halberstadt¹ reported $Q = 256.1$. See also Weiss and Neumann.¹

ZrO₂ (c, ppt.). We have estimated the heat of hydration of ZrO₂ (c, monoclinic) to be -5.

ZrCl₄ (c). Beck¹ measured the heat of solution of this substance in aqueous ammonia to be 54.3, that is, for ZrCl₄ (c) + 4 NH₄OH (aq.) = ZrO₂ (c, ppt.) + 4 NH₄Cl (aq.) + 2 H₂O (liq.), $Q = 54.3$; whence, for ZrCl₄ (c), $Q_f = 268.9$. Roth and Schwartz¹ and Roth and Becker³ estimated a much lower value.

ZrOSO₄ · SO₃ (c). Beck¹ measured the heat of solution of this substance in aqueous sodium hydroxide to be 36.7; Chauvenet⁶ found 32.78 for the heat of solution in water. These data yield, for ZrOSO₄ · SO₃ (c), $Q_f = 566.3$ and 506.5.

ZrOCl₂ (aq.). Aqueous zirconium tetrachloride may be considered to be (ZrOCl₂ + 2 HCl) (aq.). The data of Chauvenet⁵ suggested a value for the heat of neutralization of this solution: (ZrOCl₂ + 2 HCl) (aq.) + 2 NaOH (aq.) = (ZrOCl₂ + 2 NaCl) (aq.) + 2 H₂O (liq.), $Q = 27.0$, and ZrOCl₂ (aq.) + 2 NaOH (aq.) = ZrO₂ (c, ppt.) + 2 NaCl (aq.) + H₂O (liq.), $Q = 19.0$. These data yield, for ZrOCl₂ (aq.), $Q_f = 272.5$.

ZrO⁺⁺ (aq.). This value is obtained from that for ZrOCl₂ (aq.).

ZrOBr₂ (aq.). This value is obtained from those for the ions, ZrO⁺⁺ (aq.) and Br⁻ (aq.).

ZrOSO₄ (aq.). This value is obtained from the aqueous ions.

ZrO (NO₃)₂ (aq.). This value is obtained from the aqueous ions.

ZrOCl₂ · nH₂O (c). Chauvenet³ measured the heats of solution of the hydrates with 2, 3½, 6, and 8 H₂O.

ZrOBr₂ · nH₂O (c). Chauvenet⁶ measured the heats of solution of the hydrates with 3½ and 8 H₂O.

ZrO (NO₃)₂ · nH₂O (c). Chauvenet and Nicolle¹ measured the heats of solution of the hydrates with 2, 3, 3½, and 6 H₂O.

ZrOSO₄ · 4 H₂O (c). Chauvenet⁷ measured the heat of solution.

ZrOSO₄ · H₂SO₄ (c). Chauvenet⁷ measured the heat of solution.

ZrC (c). Prescott¹ studied the equilibrium, ZrO₂ (c) + 3 C (c) = ZrC (c) + 2 CO (g), and calculated $Q^{25} = -160$.

HAFNIUM

Hf (c). Standard state.

HfO₂ (c, monoclinic). Roth and Becker³ measured the heat of combustion of hafnium, to form monoclinic hafnium dioxide, to be 271.5.

THORIUM

Th (c). Standard state.

Th (g). We have estimated the heat of sublimation. See also Andrews.¹⁸

ThO₂ (c). For the heat of combustion of thorium to form crystalline thorium dioxide, the data of von Wartenberg,⁶ Chauvenet,⁶ and Roth and Becker³ yield 327.2, 330.2, and 292.6, respectively.

ThH₄ (c). Dissociation pressure data on thorium hydride were reported by Chauvenet⁴ and Matignon and Delepine.¹

ThCl₄ (aq.). Chauvenet² measured the heat of solution of thorium in aqueous (13%) HCl to be 238.5, whence, for ThCl₄ (aq.), $Q_f = 392$.

ThCl₄ (c). For the heat of solution of solid thorium tetrachloride in water, Chauvenet² found 56.7 at 15° and von Wartenberg 53. For the heat of formation of ThCl₄ (c) by direct synthesis from a very impure sample of thorium, von Wartenberg⁶ reported $Q_f = 300$.

ThCl₄ · nH₂O (c). Chauvenet² measured the heats of solution of the di-, tetra-, penta-, and octahydrates.

Th⁺⁺⁺ (aq.). This value is obtained from ThCl₄ (aq.).

ThCl₃OH · H₂O (c). Chauvenet² measured the heat of solution.

ThOCl₂ (c). Chauvenet² measured the heat of solution.

Th(OH)₄ (c, "soluble"). Chauvenet² measured the heat of solution in HCl(15).

Th(OH)₄ (c, "insoluble"). Chauvenet² measured the heat of solution in HCl(15).

ThBr₄ (aq.). This value is obtained from the ions.

ThBr₄ (c). Chauvenet² measured the heat of solution.

ThBr₄ · *n*H₂O (c). Chauvenet² measured the heats of solution of the hepta-, deca-, and dodecahydrates.

ThOBr₂ (c). Chauvenet² measured the heat of solution.

ThI₄ (aq.). This value is obtained from the ions.

ThOI₂ (c). Chauvenet² measured the heat of solution.

ThOI₂ · 3½ H₂O (c). Chauvenet² measured the heat of solution.

ThI₃OH · 10 H₂O (c). Chauvenet² measured the heat of solution.

Th(SO₄)₂ (aq.). This value is obtained from the ions.

Th(SO₄)₂ (c). Beck¹ reported the improbably low value of 22.5 for the heat of reaction of solid thorium sulfate with aqueous sodium hydroxide. From his data, Beck derived in some unstated manner the value 115.5 for the heat of the reaction of ThO₂ (c) with 2 SO₃ (g). These values yield, for Th(SO₄)₂ (c), *Q*_f = 526.9 and 596 respectively. We have estimated the value 632.

Th(SO₄)₂ · *n*H₂O (c). Koppel¹ determined the heat of hydration of the tetra- to the octahydrate from measurement of their heats of solution in aqueous potassium carbonate, and also from solubility measurements. The latter data yield 5.0 and -7.5 for the heats of solution of the tetra- and octahydrates.

ThOSO₄ (c). Wohler, Pluddemann, and Wohler¹ obtained dissociation pressure data on the reaction, ThO₂ · 2 SO₃ (c) = ThO₂ · SO₃ (c) + SO₃ (g).

Th₃N₄ (c). Neumann, Kroger, and Haebler³ determined the heat of formation of this compound.

ThCl₄ · 2 NH₄Cl · *n*H₂O (c). Chauvenet^{1, 2} measured the heats of solution of the anhydrous double salt and of the decahydrate.

ThCl₄ · *n*NH₃ (c). Chauvenet^{1, 2} measured the heats of solution in aqueous HCl of these regular amines with *n* = 4, 6, 7, 12, and 18.

[Th · 6 NH₃]Cl₄ · *n*NH₃ (c). Chauvenet^{1, 2} measured the heats of solution in aqueous HCl of these "coordination valence" amines with *n* = 0, 1, 6, and 12.

ThC₂ (c). From equilibrium studies, Prescott and Hincke¹ computed *Q*²⁵ = -194.8 for the reaction, ThO₂ (c) + 4 C (c) = ThC₂ (c) + 2 CO (g).

BORON

B (c). Standard state.

B (g). We have estimated the heat of vaporization. The energy states of gaseous monatomic boron have been evaluated from the data of Bowen,² Sawyer and Smith,¹ Millikan,¹ and Bowen and Millikan.⁵

BO (g). Mulliken⁶ reported a value for the energy of dissociation.

BO₂⁻ (aq.), BO₃⁻⁻⁻ (aq.), B₄O₇⁻ (aq.). The values for these ions are obtained from those for the respective sodium salts in aqueous solution.

B₂O₃ (gls.). For the heat of solution of this substance, Berthelot⁵⁰ reported 7.3, Ditte¹ gave 3.16. Mulert¹ found 29.6 for its heat of solution in aqueous HF.

B₂O₃ (aq.). This is taken as equivalent to 2 H₃BO₃ (aq.) - 3 H₂O (liq.).

BH (g). Mulliken⁶ reported a value for the energy of dissociation.

B₂H₆ (g). Stelzner and Niederschulte¹ obtained vapor pressure data.

HBO₂ (c). Gilbert and Levi¹ obtained dissociation pressure data on B₂O₃ · H₂O (c) (= 2 HBO₂ (c)).

H₃BO₃ (aq.). The data of Troost and Hautefeuille^{4, 5} on the heat of solution of BCl₃ (g) in water yield $Q = 70.3$, when corrected according to Berthelot.^{50, 151} Berthelot^{50, 151} measured the heat of solution of BCl₃ (liq.) in water to be 65.8 at 10°.

H₃BO₃ (c). The data on the heat of solution are: Thomsen,¹⁵ -5.39₄₀₀; Berthelot,⁵² -4.8₂₀₀¹⁵; Ditte,¹ -3.2; Linderstrom-Lang,¹ -5.0. See also Favre and Valson.²

H₂B₄O₇ (c). Gilbert and Levi¹ measured the dissociation pressures of 2 B₂O₃ · H₂O (c).

H₂B₆O₁₀ (c). Gilbert and Levi¹ measured the dissociation pressures of 3 B₂O₃ · H₂O (c).

nB₂O₃ · H₂O (c). Gilbert and Levi¹ reported dissociation pressure data on these hydrates with $n = 4, 5, 6, 7$, and 8, but the existence of these as definite compounds has not been fully established.

BF₃ (aq.). Thomsen¹⁵ measured the heat of mixing H₃BO₃ (aq.) with 3 HF (aq.).

HBf₄ (aq.). Thomsen¹⁵ measured the heat of mixing H₃BO₃ (aq.) with 4 HF (aq.).

BF₄⁻ (aq.). The heat of ionization of aqueous HBF₄ is assumed to be zero.

BF₃ (g). Hammerl² measured the heat of solution of this gas.

BF₃ (liq.). Ruff and Bretschneider¹ measured the vapor pressure of the liquid. See also LeBoucher, Fischer, and Biltz.¹

BCl₃ (g). The data of Troost and Hautefeuille^{4, 5} corrected according to Berthelot,^{50, 151} yield for the reaction, B (c) + 1½ Cl₂ (g) = BCl₃ (g), $Q = 89.1$.

BCl₃ (liq.). For the heat of vaporization of the liquid, Berthelot⁵⁰ reported -4.5¹⁰; the vapor pressure data of Stock and Priess¹ yield -6.34 at 18°.

BBr₃ (liq.). Berthelot^{50, 151} measured the heat of reaction of BBr₃ (liq.) with 400 H₂O to be 83.8 at 11°.

BBr₃ (g). Stock and Russ¹ measured the vapor pressure of the liquid.

B₂H₅Br (liq.). Stock, Russ, and Priess¹ measured the vapor pressure.

B(CH₃)₃ (liq.). Stock and Zeidler¹ measured the vapor pressure.

B₂S₃ (c). Sabatier^{3, 6} measured the heat of solution of this substance. See also Stock and Pappenberg.¹

NH₄BO₂ (aq.). Berthelot⁴ measured the heat of reaction of NH₃ (aq.) with H₃BO₃ (aq.) to be 8.93.

$(\text{NH}_4)_2\text{HBO}_3$ (aq.). Berthelot⁴ measured the heat of reaction of 2NH_3 (aq.) with H_3BO_3 (aq.) to be 11.55.

$(\text{NH}_4)_3\text{BO}_3$ (aq.). Berthelot⁴ measured the heat of reaction of 3NH_3 (aq.) with H_3BO_3 (aq.) to be 12.62.

CuB_2O_4 (c). Parravano and Malquori⁴ studied the equilibrium, $6 \text{CuB}_2\text{O}_4$ (c) = $3 \text{Cu}_2\text{O} \cdot 2 \text{B}_2\text{O}_3$ (c) + $4 \text{B}_2\text{O}_3$ (c) + $1\frac{1}{2} \text{O}_2$ (g).

NH_4BO_3 (c). Tanatar⁹ measured the heat of decomposition of ammonium perborate with sulfuric acid, and also its heat of solution.

ALUMINUM

Al (c). Standard state. Laschtschenko⁵ reported a transition at 590° , but this has not been confirmed.

Al (liq.). The data on the heat of fusion at 658° are: Pionchon,¹ -2.13 ; Laschtschenko,⁶ -1.92 ; Wust, Meuthen, and Durrer,¹ -2.54 .

Al (g). We have estimated the heat of sublimation. See also Sherman¹ and Millar.¹ The energy states of gaseous monatomic aluminum have been evaluated from the data of Fowler,³ Sawyer and Paschen,¹ Paschen,⁶ Lyman,¹ and Soderquist.^{1, 2}

Al_2O_3 (c). Berthelot,¹²⁷ Moose and Parr,¹ and Roth and Muller⁴ measured the heat of combustion of aluminum in oxygen in a bomb. The data of the latter two modern investigations yield, for Al_2O_3 (c), $Q_f = 376.9$ and 380.1 , respectively. See also Mixer¹⁶ and Baille and Fery.¹

Al_2O_3 (g). Vapor pressure data were obtained by Ruff and Konshak.¹ See also Ruff and Schmidt¹ and Millar.¹

AlH (g). Bengtsson and Rydberg² reported the energy of dissociation. See also Villars and Condon.¹

AlCl_3 (aq.). The heat of solution of aluminum in aqueous hydrochloric acid was measured by Sommermeier,¹ Richards and Burgess,¹ Biltz and Hohorst,¹ and Richards, Rowe, and Burgess.¹ The data of the last named investigation yield, for AlCl_3 (600), $Q_f = 244.7$.

Al^{+++} (aq.). This value is obtained from that for AlCl_3 (aq.). See also Latimer.¹

AlCl_3 (c). The data on the heat of solution of this substance in water are: Thomsen,¹⁵ 76.85_{1250} ; Berthelot,⁵⁰ 76.3^9 ; Baud,^{1, 2} 77.6_{3000}^{14} ; Sabatier,² 78 .

AlCl_3 (liq.). Maier¹ reported a value for the heat of fusion.

Al_2Cl_6 (g). The vapor of aluminum chloride is completely associated at low temperatures. The vapor pressure data of Maier¹ yield -27.5 for the heat of sublimation at 100° .

AlCl_3 (g). The meager vapor density data of Nilson and Patterson² yield about -40 for the heat of the reaction, Al_2Cl_6 (g) = 2AlCl_3 (g).

$\text{AlCl}_3 \cdot 6 \text{H}_2\text{O}$ (c). Sabatier² measured the heat of solution.

$\text{Al}(\text{OH})_3$ (c). Baud,¹ Berthelot,⁵⁰ and Thomsen¹⁵ measured the heat of reaction of AlCl_3 (aq.) with $3 \text{NH}_4\text{OH}$ (aq.).

AlF_3 (aq.). Petersen⁴ and Mulert¹ measured the heats of mixing AlCl_3 (aq.) with 3HF (aq.) and AlF_3 (aq.) with 3HCl (aq.).

H_3AlF_6 (aq.). Berthelot¹⁵¹ and Mulert¹ measured the heat of mixing AlF_3 (aq.) with 3 HF (aq.).

AlF_3 (c). Baud¹ estimated the heat of solution.

$\text{AlF}_3 \cdot n\text{H}_2\text{O}$ (c). Baud¹ measured the heats of solution, in aqueous (19%) HF , of the hemihydrate and the "soluble" and "insoluble" forms of the hydrate with $3\frac{1}{2} \text{ H}_2\text{O}$.

AlBr_3 (aq.). Berthelot⁵⁰ measured the heat of reaction of this solution with $3 \text{ NH}_4\text{OH}$ (aq.). See also Roos.²

AlBr_3 (c). For the heat of solution, Berthelot⁵⁰ found 85.3_{3000}^9 and Gustavson¹ 90.0.

AlBr_3 (liq.). For the heat of fusion of aluminum bromide, Fischer² found -2.7 at 98° and Pickering¹² -2.17 at 95° .

AlI_3 (aq.). This value is obtained from those for the ions.

AlI_3 (c). Berthelot⁵⁰ measured the heat of solution.

AlI_3 (liq.). Fischer² reported a value for the heat of fusion.

Al_2S_3 (c). Sabatier¹ measured the heat of the reaction, Al_2S_3 (c) + $6 \text{ H}_2\text{O}$ (liq.) = $2 \text{ Al(OH)}_3 + 3 \text{ H}_2\text{S}$ (g), to be 75.0.

$\text{Al}_2(\text{SO}_4)_3$ (aq.). Thomsen¹⁵ measured the heat of reaction of $\text{Al}_2(\text{SO}_4)_3$ (aq.) with 3 BaCl_2 (aq.) and with 6 KOH (aq.).

$\text{Al}_2(\text{SO}_4)_3$ (c). Wohler, Pluddemann, and Wohler¹ measured the dissociation pressure of $\text{Al}_2\text{O}_3 \cdot 3 \text{ SO}_3$ (c) at various temperatures, and their data yield, for $\text{Al}_2(\text{SO}_4)_3$ (c), $Q_f = 713$. We have estimated, from the heat of dehydration of the hexahydrate, for $\text{Al}_2(\text{SO}_4)_3$ (c), $Q_f = 770$.

$\text{Al}_2(\text{SO}_4)_3 \cdot n\text{H}_2\text{O}$ (c). Favre and Silbermann³ measured the heat of solution of the hexahydrate, and Favre and Valson² that of the octadecahydrate.

$\text{AlCl}_3 \cdot n\text{SO}_2$ (c). Baud¹ measured the heats of solution of these compounds with $\frac{1}{2}$ and 1 mole of SO_2 , respectively.

$\text{AlX}_3 \cdot n\text{H}_2\text{S}$ (c). Biltz and Keuncke¹ obtained dissociation pressure data on $\text{AlCl}_3 \cdot \text{H}_2\text{S}$ (c), $\text{AlBr}_3 \cdot \text{H}_2\text{S}$ (c), $\text{AlI}_3 \cdot 4 \text{ H}_2\text{S}$ (c), and $\text{AlI}_3 \cdot \text{H}_2\text{S}$ (c). Baud¹ measured the heat of solution of $\text{AlCl}_3 \cdot \frac{1}{2} \text{ H}_2\text{S}$ (c).

AlN (c). The data of Fichter and Jenny,¹ who measured the heats of combustion of Al (c) and AlN (c), yield, for the latter, $Q_f = 23$. Matignon¹³ estimated $Q_f = 110$. The data of Prescott and Hincke,^{1, 2} who studied the equilibria, $2 \text{ Al}_2\text{O}_3$ (c) + 9 C (c) = Al_4C_3 (c) + 6 CO (g) and 4 AlN (c) + 3 C (c) = Al_4C_3 (c) + 2 N_2 (g), yield, for $2 \text{ Al}_2\text{O}_3$ (c) + 6 C (c) + 2 N_2 (g) = 6 CO (g) + 4 AlN (c), $Q = -277$, and for AlN (c), $Q_f = 80$.

$\text{AlF}_3 \cdot 2 \text{ NH}_4\text{F} \cdot 1\frac{1}{2} \text{ H}_2\text{O}$ (c). Baud¹ measured the heat of solution.

$\text{AlCl}_3 \cdot n\text{NH}_3$ (c). Klemm and Tanke¹ reported the following heats of dissociation, from dissociation pressure data, per mole of gaseous ammonia, to the next lower ammine: tetradecamine, -7.8 ; heptamine, -10.2 ; hexamine, -13.1 ; pentamine, -17.7 . Klemm and Tanke¹ measured the following heats of solution in $\text{HCl}(20)$ at 0° : Hexamine, 73.4; pentamine, 65.1; triamine, 58.0; monamine, 60.3. Baud¹ reported the following heats of solution in water at 15° : hexamine,

6.35₂₄₀₀; pentammine, 9.05₂₂₀₀; triammine, 30.3₂₀₀₀; monammine, 53.05. Baud¹ reported 7.94 for the heat of solution and -8.27 for the heat of dissociation of the nonammine, but the existence of this compound is doubtful. See also Ephraim and Millman.¹

$\text{AlCl}_3 \cdot \text{NH}_4\text{Cl} \cdot 6 \text{NH}_3$ (c). Baud¹ measured the heat of solution.

$\text{AlCl}_3 \cdot \text{NH}_4\text{Cl}$ (c). Baud¹ measured the heat of solution.

$\text{AlBr}_3 \cdot n \text{NH}_3$ (c). Klemm and Tanke¹ reported the following heats of dissociation: tetradecammine, -7.72; nonammine, -8.4; heptammine, -10.7; hexammine, -16.2. Klemm and Tanke¹ measured the following heats of solution in HBr(20) at 0°: hexammine, 66.4; pentammine, 60.2; triammine, 57.7; monammine, 66.9. See also Ephraim and Millman.¹

$\text{AlI}_3 \cdot n \text{NH}_3$ (c). Klemm and Tanke¹ reported dissociation pressure data on the amines with 20, 13, 9, and 7 NH_3 . Klemm and Tanke¹ measured the heats of solution in HI(20) at 0° of the amines with 6, 5, 3, and 1 NH_3 . See also Ephraim and Millman.¹

$\text{NH}_4\text{Al}(\text{SO}_4)_2 \cdot n \text{H}_2\text{O}$ (c). Favre and Silbermann³ measured the heat of solution of the dodecahydrate. Ephraim and Wagner¹ obtained dissociation pressure data on the system, dodecahydrate-pentahydrate-water vapor, finding $D = -14.4$.

$\text{AlX}_3 \cdot \text{PH}_3$ (c). Holtje¹ obtained dissociation pressure data on the chloride, bromide, and iodide.

Al_4C_3 (c). Prescott and Hincke^{1, 2} studied the equilibrium, $2 \text{Al}_2\text{O}_3$ (c) + 9 C (c) = Al_4C_3 (c) + 6 CO (g), and calculated $Q = -539$; whence, for Al_4C_3 (c), $Q_f = 60$. See also Berthelot.¹²⁶

Al_2SiO_5 (c). Neumann² measured the heats of solution of andalusite, disthene, and sillimanite in aqueous (20%) HF.

$3 \text{Al}_2\text{O}_3 \cdot 2 \text{SiO}_2$ (c). Neumann² measured the heat of solution of mullite in aqueous (20%) HF.

$2 \text{AlCl}_3 \cdot 3 \text{PbI}_2 \cdot n \text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the decahydrate.

$\text{AlCl}_3 \cdot \frac{3}{2} \text{ZnCl}_2$ (c). Baud¹ measured the heat of solution.

$\text{AlCl}_3 \cdot \text{AgCl}$ (c). Baud¹ measured the heat of solution.

AlCu_n (c). Rolla² measured the heats of solution in bromine water of AlCu (c), Al_2Cu (c), and AlCu_3 (c) to be 181.4, 365.9, and 303.7, respectively; for Al_2Cu (c), Roos² found 423.

Al_3Fe (c). Biltz and Haase¹ measured the heat of solution in HCl(8).

Al_nCo (c). Biltz and Haase¹ measured the heat of solution in HCl(8) of AlCo (c) and Al_5Co (c).

SCANDIUM

Sc (c). Standard state.

Sc (g). We have estimated the heat of sublimation. The values of the energy states of gaseous monatomic scandium are from Russell and Meggers.¹

Sc_2O_3 (c). Roth and Becker³ estimated $Q_f = 407$.

ScCl_3 (c). Roth and Becker³ estimated $Q_f = 202$.

YTTRIUM

Y (c). Standard state.

Y (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic yttrium are from Meggers and Russell.¹

YCl₃ (c). We have estimated the value for the heat of formation of this substance to be 240. Roth and Becker³ estimated 243.

YCl₃ (aq.). Matignon⁷ measured the heat of solution of solid yttrium chloride.

Y₂(SO₄)₃ (aq.). Thomsen¹⁵ measured the heat of reaction of this solution with 3 BaCl₂ (aq.).

Y₂(SO₄)₃ · 8 H₂O (c). Thomsen¹⁵ measured the heat of solution.

Y(OH)₃ (c). Thomsen¹⁵ measured the heat of reaction of aqueous yttrium sulfate with aqueous barium hydroxide.

Y₂O₃ (c). Roth and Becker³ estimated $Q_f = 441$.

Y⁺⁺⁺ (aq.). This value is obtained from that for aqueous yttrium chloride.

LUTECIUM

Lu (c). Standard state.

YTTERBIUM

Yb (c). Standard state.

THULIUM

Tm (c). Standard state.

ERBIUM

Er (c). Standard state.

Er⁺⁺⁺ (aq.). We have estimated the value for aqueous erbium ion.

Er(C₂H₃O₂)₃ (aq.). The value for aqueous erbium acetate is obtained from the ions.

Er(OH)₃ (c, ppt.). Thomsen¹⁵ measured the heat of reaction of Er (C₂H₃O₂)₃ (1500) with 1½ Ba(OH)₂ (400) to be 12.8.

Er(C₂H₃O₂)₃ · 4 H₂O (c). Thomsen¹⁵ measured the heat of solution.

HOLMIUM

Ho (c). Standard state.

DYSPROSIUM

Dy (c). Standard state.

TERBIUM

Tb (c). Standard state.

GADOLINIUM

Gd (c). Standard state.

EUROPIUM

Eu (c). Standard state.

SAMARIUM

Sa (c). Standard state.

Sa⁺⁺⁺ (aq.). We have estimated the value for aqueous samarium ion.

SaCl₃ (aq.). This value is obtained from those for the ions.

SaCl₃ (c). Matignon⁵ measured the heat of solution.

Sa₂O₃ (c). Matignon⁵ measured the heat of solution of the regular oxide to be 94.6 in HCl (aq.), and that of the oxide prepared from the oxalate to be 90 in HCl (aq.).

SaCl₃ · nNH₃ (c). Matignon and Trannoy¹ obtained dissociation pressure data on the ammines with 1, 2, 3, 4, 5, 8, 9½, and 11½ NH₃.

ILLINIUM

Il (c). Standard state.

NEODYMIUM

Nd (c). Standard state.

Nd₂O₃ (c). Muthmann and Beck¹ measured the heat of combustion of neodymium to be 434.8. We have labeled this the "high temperature" form, and have estimated the heat of formation of the "low temperature" form (as prepared from neodymium nitrate, for example) to be 427.

NdCl₃ (aq.). Matignon^{8, 17} measured the heat of solution of Nd₂O₃ (c, "low temperature"), prepared from the nitrate, to be 105.5 in HCl(110).

Nd⁺⁺⁺ (aq.). This value is obtained from that of aqueous neodymium chloride.

NdCl₃ (c). Matignon^{8, 17} measured the heat of solution.

NdCl₃ · 6 H₂O (c). Matignon^{8, 17} measured the heat of solution.

NdI₃ (aq.). Matignon^{8, 17} measured the heat of solution of Nd₂O₃ (c, "low temperature"), prepared from the nitrate, to be 106.1 in HI(110).

NdI₃ (c). Matignon^{8, 17} measured the heat of solution.

Nd₂(SO₄)₃ (aq.). Matignon^{8, 17} measured the heat of solution of Nd₂O₃ (c, "low temperature"), prepared from the nitrate, to be 106.4 in H₂SO₄(220).

Nd₂(SO₄)₃ · nH₂O (c). Matignon^{8, 17} measured the heats of solution of the anhydrous salt and the penta- and octahydrates.

Nd₂S₃ (c). Matignon^{8, 17} measured the heat of solution of this sulfide in HCl(110).

NdCl₃ · nNH₃ (c). Matignon and Trannoy¹ obtained dissociation pressure data on the ammines with 1, 2, 4, 5, 8, 11, and 12 NH₃.

PRASEODYMIUM

Pr (c). Standard state.

PrCl₃ (aq.). Sieverts and Gotta² measured the heat of solution of praseodymium in HCl(25) to be 168.9.

Pr⁺⁺⁺ (aq.). This value is obtained from PrCl₃ (aq.).

PrCl₃ (c). Matignon⁵ measured the heat of solution.

$\text{PrCl}_3 \cdot n\text{H}_2\text{O}$ (c). Matignon⁵ measured the heats of solution of the mono- and heptahydrates.

Pr_2O_3 (c). Matignon⁵ measured the heat of solution of this oxide in aqueous hydrochloric acid to be 106.2. By direct combustion of praseodymium, Muthmann and Beck¹ found $Q_f = 417$.

$\text{Pr}(\text{NO}_3)_3$ (aq.). Prandtl and Huttner¹ measured the heat of solution of Pr_2O_3 (c) in HNO_3 (6) to be 109.5.

PrO_2 (c), Pr_6O_{11} (c). Prandtl and Huttner¹ measured the heats of solution of these oxides in HNO_3 (6). The products of the reaction were aqueous praseodymium nitrate and gaseous oxygen.

CERIUM

Ce (c). Standard state.

CeO_2 (c). For the heat of combustion of cerium to form CeO_2 (c), the data of Moose and Parr,¹ Muthmann and Weiss,¹ and Hirsch¹ yield 233.4, 226, and 245, respectively.

CeCl_3 (aq.). The data on the heat of solution of cerium in aqueous hydrochloric acid are: Biltz and Pieper,¹ 164.9 in HCl (20), 166.4 in HCl (8); Neumann, Kroger, and Kunz,¹ 165.2 in HCl (20); Sieverts and Gotta,² 168.7 in HCl (25).

CeCl_3 (c). The heat of solution has been estimated by us.

Ce_3H_8 (c). Sieverts and Gotta² measured the heats of solution of Ce (c) in HCl (25) and of Ce_3H_8 (c) in HCl (50).

Ce^{+++} (aq.). This value is obtained from that for aqueous CeCl_3 .

$\text{Ce}(\text{OH})_3\text{OOH}$ (c). Pissarjewsky¹ measured the heat of reaction of this hydrated peroxide with aqueous sulfuric acid to be 30.0. The reaction is $2 \text{Ce}(\text{OH})_3\text{OOH}$ (c) + $3 \text{H}_2\text{SO}_4$ (aq.) = $(\text{Ce}_2(\text{SO}_4)_3 + \text{H}_2\text{O}_2)$ (aq.) + $6 \text{H}_2\text{O}$ (liq.) + O_2 (g).

$\text{Ce}_2(\text{SO}_4)_3$ (aq.). Thomsen¹⁵ measured the heat of reaction of this solution with 3BaCl_2 (aq.).

$\text{Ce}(\text{SO}_4)_2$ (c). Beck¹ reported the value for the heat of the reaction, CeO_2 (c) + 2SO_3 (g) = $\text{Ce}(\text{SO}_4)_2$ (c), to be 103.5, but there is probably a considerable uncertainty in it.

$\text{Ce}_2(\text{SO}_4)_3 \cdot 4\frac{3}{8}\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

CeN (c). Neumann, Kroger, and Kunz¹ measured the heat of solution in aqueous hydrochloric acid. See also Lipski.¹

$\text{CeCl}_3 \cdot n\text{NH}_3$ (c). Barre² obtained dissociation pressure data on the ammines with 2, 4, 8, 12, and 20 NH_3 .

CeHg_4 (c). The dissociation pressure data of Biltz and Meyer² yield $D = -19.9$ per mole of Hg (g).

Ce_3Al (c). Biltz and Pieper¹ measured the heat of solution in HCl (20). See also Zhukov.²

CeAl_4 (c). Biltz and Pieper¹ measured the heat of solution in HCl (20). Muthmann and Beck¹ reported the heat of combustion to be 832.

CeZn_4 (c). Muthmann and Beck¹ reported the heat of combustion to be 525.

LANTHANUM

La (c). Standard state.

La (g). We have estimated the heat of sublimation. The values for the energy states of gaseous monatomic lanthanum are from Bacher and Goudsmit.¹

LaCl₃ (aq.). Neumann, Kroger, and Kunz¹ and Sieverts and Gotta¹ measured the heat of solution of lanthanum to be, respectively, 167.7 in HCl(20) and 164.5 in HCl(110); whence, for LaCl₃ (aq.), $Q_f = 284.4$ and 282.7, respectively.

LaCl₃ (c). Matignon⁷ measured the heat of solution. See also Beck.¹

La⁺⁺⁺ (aq.). This value is obtained from that for aqueous lanthanum chloride.

La₂O₃ (c). For the heat of combustion of lanthanum in oxygen to form La₂O₃ (c), Moose and Parr,¹ Muthmann and Weiss,¹ and Kremers and Stevens¹ reported 457.0, 445, and 457, respectively. Matignon⁷ and Beck¹ measured the heat of solution of La₂O₃ (c) to be, respectively, 114.6 in HCl(100) at 16° and 105 in HCl(8). These latter data yield, for La₂O₃ (c), $Q_f = 423$ and 441, respectively.

La₃H₈ (c). Sieverts and Gotta¹ measured the heats of solution of La (c) and La₃H₈ (c) in HCl(110).

La₂S₃ (c). Biltz² measured the heat of solution of this sulfide in HCl(9.4).

LaS₂ (c). Biltz² measured the heat of solution of this sulfide in HCl (9.4) to be 31.8.

La₂(SO₄)₃ (aq.). Thomsen¹⁵ measured the heat of reaction of this solution with 3 BaCl₂ (aq.).

La₂(SO₄)₃ · 8 H₂O (c). Thomsen¹⁵ measured the heat of solution.

LaN (c). Neumann, Kroger, and Haebler¹ reported $Q_f = 71.0$, from direct measurement of the formation, and measured the heat of solution of LaN (c) in HCl(20) to be 127.1. This latter value yields, for LaN (c), $Q_f = 72.8$.

LaAl₄ (c). Muthmann and Beck¹ measured the heat of combustion of this alloy.

ACTINIUM

Ac (c). Standard state.

BERYLLIUM

Be (c). Standard state.

Be (g). We have estimated the heat of sublimation. The energy states of gaseous monatomic beryllium have been evaluated from the data of Bowen and Millikan,^{3, 4} Paschen and Kruger,² Millikan and Bowen,⁴ and Edlen and Ericson.²

Be (liq.). Oosterheld¹ reported a value for the heat of fusion.

BeH (g). The data of Watson^{1, 2} yield values for the energies of excitation and of ionization of gaseous BeH, and for its energy of dissociation into gaseous atoms. See also Mulliken.⁶

BeO (g). Bengtsson¹ deduced the energy of dissociation into gaseous atoms, from spectroscopic data.

BeO (c). Mielenz and von Wartenberg¹ measured the heat of combustion of beryllium to be 136.0; Moose and Parr¹ found the value to be 134.5. See also Copeaux and Phillips.^{1, 2}

Be(OH)₂ (c). Matignon and Marchal⁴ measured the heat of reaction of the hydroxide with aqueous hydrochloric acid, and of aqueous beryllium chloride with aqueous sodium hydroxide. Thomsen¹⁵ measured the heat of reaction of aqueous beryllium sulfate with aqueous potassium hydroxide.

BeF₂ (aq.). For the heat of solution of BeO (c) in aqueous (30%) HF, Matignon and Marchal⁴ found 23.3 at 17°, and Copeaux and Phillips^{1, 2} found 20.1. For the heat of solution of Be(OH)₂ (c) in aqueous (30%) HF, Matignon and Marchal⁴ found 20.35; Mulert,¹ 20.47; and Petersen,⁴ 19.7.

H₂BeF₄ (aq.). Matignon and Marchal⁴ measured the heat of reaction of Be(OH)₂ (c) with 4 HF (aq.).

BeCl₂ (c). Mielenz and von Wartenberg¹ measured the heat of the reaction, Be (c) + Cl₂ (g) = BeCl₂ (c), to be 112.6.

BeCl₂ (aq.). The data on the heat of solution of BeCl₂ (c) in water are: Matignon and Marchal,⁴ 51.1; Pollok,¹ 44.5. For the heat of solution of BeCl₂ (c) in HCl(9), Biltz and Messerknecht² found 44.1, and in HCl (aq.), Biltz, Klatte, and Rahlfs¹ found 48.6.

Be⁺⁺ (aq.). This value is obtained from those for BeCl₂ (aq.) and BeF₂ (aq.).

BeCl₂ (g). Fischer and Rahlfs² measured the vapor pressure of the solid.

BeCl₂(C₂H₅OH). Pollok¹ measured the heat of solution of solid beryllium chloride in ethyl alcohol.

BeBr₂ (aq.). This value is obtained from those for the ions.

BeBr₂ (c). Biltz and Messerknecht² and Biltz, Klatte, and Rahlfs¹ measured the heat of solution of solid beryllium bromide in aqueous hydrochloric acid.

BeBr₂ (g). Fischer and Rahlfs² measured the vapor pressure of the solid.

BeI₂ (aq.). This value is obtained from those for the ions.

BeI₂ (c). Biltz, Klatte, and Rahlfs¹ and Biltz and Messerknecht² measured the heat of solution of solid beryllium iodide in aqueous hydrochloric acid.

BeI₂ (g). Fischer and Rahlfs² measured the vapor pressure of the solid.

BeSO₄ (aq.). Thomsen¹⁵ measured the heat of reaction of BeSO₄ (aq.) with BaCl₂ (aq.) to be 6.66; Matignon and Marchal² found 6.97.

BeSO₄ (c). Matignon and Marchal² measured the heat of solution of this solid in aqueous sodium hydroxide. Marchal^{2, 5} measured the dissociation pressure of BeO · SO₃ (c).

BeSO₄ · nH₂O (c). Matignon and Marchal² measured the heats of solution of the di- and tetrahydrates in water, and also of the tetrahydrate in aqueous sodium hydroxide. Thomsen¹⁵ measured the heat of solution of the tetrahydrate. Krauss and Gerlach¹ obtained dissociation pressure data on the mono-, di, and tetrahydrates.

BeX₂ · 2 H₂S (c). Blitz and Keunecke¹ measured the dissociation pressures of the bromide and iodide.

Be(NO₃)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of BeSO₄ (aq.) with Ba(NO₃)₂ (aq.).

BeX₂ · nNH₃ (c). Blitz, Klatte, and Rahlfs¹ measured the heats of solution of the tetrammines of the chloride, bromide, and iodide in aqueous hydrochloric acid, and Biltz and Messerknecht² obtained similar data with HCl(9). Biltz and Messerknecht² obtained dissociation pressure data on the tetra-, hexa-, and dodecammines of the chloride, on the hexa- and decammines of the bromide, and on the hexa- and tridecammines of the iodide.

MAGNESIUM

Mg (c). Standard state.

Mg (g). Wehnelt and Musceleanu¹ measured directly the heat of vaporization of magnesium. Vapor pressure data were obtained by Ditte,⁷ Greenwood,^{3, 5} von Wartenberg,⁴ Ruff and Hartmann,¹ and Hartmann and Schneider.¹ The values of the energy states of gaseous monatomic magnesium are from Fowler,³ Turner,¹ and Soderqvist.¹

Mg (liq.). Data on the heat of fusion of magnesium were reported by van Aubel,¹ Wehnelt and Musceleanu,¹ Awbery and Griffiths,¹ and Zalesenski and Zulenski.¹

MgO (c). For the heat of combustion of magnesium, the data yield the following values: Moose and Parr,¹ 146.1; Muthmann and Weiss,¹ 143.5; Rogers,¹ 147.0; von Wartenberg,⁶ 144.3.

MgH (g). Values for the energies of excitation and ionization, and for the energy of dissociation into gaseous atoms, were reported by Hulthen,¹ Watson,² and Mulliken.⁶

Mg(OH)₂ (c, ppt.). Thomsen¹⁵ measured the heat of reaction of MgSO₄ (aq.) with Ba(OH)₂ (aq.), and of MgSO₄ (aq.) with 2 KOH (aq.). Berthelot¹⁰⁰ measured the heat of reaction of KOH (aq.) with MgSO₄ (aq.) and with MgCl₂ (aq.).

Mg(OH)₂ (c, brucite). Mixer's¹⁷ data on the reactions with sodium peroxide yield -9.4 for the heat of the reaction, Mg(OH)₂ (c) = MgO (c, brucite) + H₂O (liq.). See also Johnston.⁵

MgF (g). Johnson³ reported a value for the energy of dissociation into gaseous atoms.

MgF₂ (c). Petersen³ found $Q = 29.1$ for the reaction, MgCl₂ (aq.) + 2 AgF (aq.) = MgF₂ (c) + 2 AgCl (c). Guntz¹ found -1.7 for the heat of reaction of MgSO₄ (aq.) with 2 KF (aq.).

MgCl₂ (aq.). The following are the data on the heat of solution of magnesium: Richards, Rowe, and Burgess,¹ 110.2 in 2 HCl(200); Rich-

ards and Burgess,¹ 110.15 in 2 HCl(200); Biltz and Pieper,¹ 109.7 in 2 HCl(200) and 111.2 in 2 HCl(20); Tammann and Ohler,¹ 113.1 in 2 HCl(8.7); Blitz and Hohorst,¹ 113.1 in 2 HCl(8); Sieverts and Gotta,¹ 112.1 in 2 HCl(200). Data on the heat of dilution of aqueous magnesium chloride were reported by Thomsen,¹⁵ Fricke and Havestadt,¹ Dunnington and Hoggard,¹ Arrhenius,² and Lange and Streeck.¹

Mg⁺⁺(∞). This value is obtained from those for MgCl₂(∞) and Cl⁻(∞). See also Latimer.²

MgCl₂(c). The data on the heat of solution are: Thomsen,¹⁵ 35.90₈₀₀; Berthelot and Ilosvay,¹ 35.5.

MgCl₂ · nH₂O(c). Thomsen's¹⁵ data on the hydrates yield for S₄₀₀: dihydrate, 20.4; tetrahydrate, 10.0; hexahydrate, 2.94. Berthelot and Ilosvay¹ and van't Hoff, Kenrick, and Dawson¹ measured the heat of solution of the hexahydrate. Vapor pressure data on the hexahydrate were reported by Lescoeur,^{4, 7} Derby and Yngve,¹ and Biltz.⁸

MgCl₂ · 6 H₂O(liq.). Reisenfeld and Milchsach¹ reported the heat of fusion of the hexahydrate.

MgCl₂ · MgO · nH₂O(c). Andre¹ measured the heats of solution of the anhydrous solid and the hexa- and hexadecahydrates, but the order of his values seems irregular.

MgOHCl(c). Moldenhauer's¹ data on the equilibrium, MgCl₂(c) + H₂O(g) = MgOHCl(c) + HCl(g), yield Q = 5.1.

MgBr₂(aq.). The value for MgBr₂(∞) is obtained from Mg⁺⁺(∞) and Br⁻(∞). Data on the heat of dilution of aqueous magnesium bromide were reported by Lange and Streeck.¹

MgBr₂(c). Beketoff⁵ measured the heat of solution.

MgBr₂ · nH₂O(c). Dissociation pressure data on the di- and hexahydrates were obtained by Lescoeur.⁵

MgI₂(aq.). The value for MgI₂(∞) is obtained from the ions. Thomsen¹⁵ measured the heat of reaction of BaI₂(aq.) with MgSO₄(aq.), and his data yield, for MgI₂(800), Qf = 136.6. We have estimated the heat of dilution of aqueous magnesium iodide.

MgI₂(c). Beketoff⁵ measured the heat of solution. See also Cambi and Devoto.¹

MgSO₄(aq.). Thomsen¹⁵ measured the heats of mixing MgCl₂(200) with H₂SO₄(200), and MgSO₄(200) with 2 HCl(100), to be 0.93 and -2.59, respectively; whence, for MgSO₄(200), Qf = 325.28. Thomsen¹⁵ also measured the heat of reaction of MgSO₄(aq.) with BaCl₂(aq.). Ditte⁵ measured the heat of solution of magnesium in aqueous sulfuric acid. Data on the heat of dilution of aqueous magnesium sulfate were reported by Thomsen,¹⁵ Rümelin,¹ Lange and Messner,² and Lange and Streeck.²

MgSO₄(c). The data on the heat of solution are: Thomsen¹⁵, 20.28₄₀₀; Pickering,^{3, 5} 20.32₄₅₀. Values were also reported by Berthelot and Ilosvay.¹

MgSO₄ · nH₂O (c). Thomsen's¹⁵ data yield the following values for S_{400} : monohydrate, 13.30; dihydrate, 11.05; tetrahydrate, 4.20; pentahydrate, 2.10; hexahydrate, 0.10; heptahydrate, -3.80. Pickering^{3, 5} reported the following values for the heats of solution: monohydrate, 12.13₄₅₀²²; heptahydrate, -3.85₄₅₀. Berthelot and Ilosvay,¹ Favre,⁷ and Graham¹ reported values for the heat of solution of the monohydrate, and van Deventer and van der Stadt¹ for the heptahydrate. Dissociation pressure data on these hydrates were reported by Frowein,¹ Lescœur,^{2, 4} Linebarger,¹ Cohen and Visser,¹ Hollmann,¹ Foote and Scholes,¹ Bolte,¹ Schumb,¹ Carpenter and Jette,¹ and Rolla and Accame.¹ Marchal¹⁵ reported dissociation pressure data on MgO · SO₃ (c).

MgSO₃ · nH₂O (c). Hartog¹ measured the heats of solution of the anhydrous salt and the tri- and hexahydrates in HCl(220).

MgS (aq.). Thomsen¹⁵ measured the heat of reaction of H₂S (aq.) with Mg(OH)₂ (c).

MgS (c). Sabatier¹ measured the heat of solution of this solid sulfide in aqueous hydrochloric acid.

Mg(HS)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of Mg(OH)₂ (c) with 2 H₂S (aq.).

MgS₂O₆ (aq.). Thomsen¹⁵ measured the heat of reaction of MgSO₄ (aq.) with BaS₂O₆ (aq.).

MgS₂O₆ · 6 H₂O (c). Thomsen¹⁵ measured the heat of solution.

Mg₃N₂ (c). For the heat of solution of this nitride, Matignon¹⁹ found 279.7 in H₂SO₄ (aq.); Moser and Herzner¹ 269.9 in H₂SO₄ (aq.); Neumann, Kroger, and Kunz,¹ 284.8 in HCl(20); Brunner¹ (see Neumann, Kroger, and Kunz¹), 177.0 in water. Neumann, Kroger, and Haebler,² by direct measurement, found $Q_f = 116$. These values yield, respectively, for Mg₃N₂ (c), $Q_f = 137, 127, 112, 108$, and 116.

Mg(NO₃)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of MgSO₄ (200) with Ba(NO₃)₂(200) to be 4.94; whence, for Mg(NO₃)₂(400), $Q_f = 208.8$. Data on the heat of dilution of aqueous magnesium nitrate were reported by Thomsen,¹⁵ Dunnington and Hoggard,¹ Lange and Streeck,² and Hammerschmid and Lange.¹

Mg(NO₃)₂ · 6 H₂O (c). For the heat of solution of this hydrate, Thomsen¹⁵ found -4.22₄₀₀ and Pickering⁸ -4.54₄₀₀.

Mg(NO₃)₂ · 6 H₂O (liq.). Reisenfeld and Milchsack¹ reported the heat of fusion of the hexahydrate.

MgCl₂ · nNH₃ (c). Dissociation pressure data were reported on the mono- and diammines by Biltz and Hüttig⁴ and Biltz, Klatte, and Rahlfs,¹ and on the hexammines by Ephraim,⁹ Bonnefoi,¹ and Biltz and Stolnwerk.²

MgCl₂ · 2NH₃ (aq.). Berthelot¹⁰⁰ estimated the heat of mixing MgCl₂ (aq.) with 2 NH₃ (aq.).

Mg(NH₃)₂⁺⁺ (aq.). This value is obtained from that for MgCl₂ · 2 NH₃ (aq.).

MgBr₂ · nNH₃ (c). Biltz and Hüttig⁴ and Biltz, Klatte, and Rahlfs¹

obtained dissociation pressure data on the mono- and diammines, and Ephraim⁹ on the hexammine.

MgI₂ · nNH₃ (c). Biltz and Hüttig⁴ and Biltz, Klatte, and Rahlfs¹ reported dissociation pressure data on the diammine, and Ephraim⁹ on the hexammine.

3 MgSO₃ · (NH₄)₂SO₃ · nH₂O (c). Hartog¹ measured the heats of solution in HCl (aq.) of the hexa- and octadecahydrates.

MgSO₄ · (NH₄)₂SO₄ · nH₂O (c). Berthelot¹⁵¹ measured the heat of solution of the hexahydrate. See also Graham.² Caven and Ferguson² studied the equilibrium, hexahydrate-dihydrate-water vapor.

Mg₃(PO₄)₂ (c, ppt.). Berthelot^{102, 145} measured the heat of the reaction, $2 \text{Na}_3\text{PO}_4 \text{ (aq.)} + 3 \text{MgSO}_4 \text{ (aq.)} = \text{Mg}_3(\text{PO}_4)_2 \text{ (c, ppt.)} + 3 \text{Na}_2\text{SO}_4 \text{ (aq.)}$.

MgHPO₄ (aq.). Berthelot^{102, 145} measured the heat of the reaction of MgSO₄ (aq.) with Na₂HPO₄ (aq.).

MgNH₄PO₄ · 6 H₂O (c). Berthelot^{102, 145} measured the heat of mixing MgCl₂ · 2 NH₃ (aq.) with Na₂HPO₄ (aq.).

Mg₃(AsO₄)₂ (c, ppt.). Blarez³ measured the heat of reaction of 2 H₃AsO₄ (aq.) with 3 Mg(OH)₂ (c).

MgHAsO₄ (aq.). Blarez³ measured the heat of reaction of H₃AsO₄ (aq.) with Mg(OH)₂ (c).

Mg(H₂AsO₄)₂ (aq.). Blarez³ measured the heat of reaction of 2 H₃AsO₄ (aq.) with Mg(OH)₂ (c).

MgNH₄AsO₄ · 6 H₂O (c). Berthelot^{102, 145} measured the heat of mixing MgCl₂ · 2 NH₃ (aq.) with H₃AsO₄ (aq.).

MgCO₃ (c). Berthelot¹² measured the heat of reaction of MgSO₄ (aq.) with Na₂CO₃ (aq.). Dissociation pressure data were obtained by Johnston,⁵ Marcy and Kimek,¹ Brill,² Friedrich,¹ Hempel and Schubert,¹ Hedvall,¹ Grunberg,¹ Manchot and Lorenz,¹ and Centnerswer and Bruczs.² The calorimetric and the equilibrium data yield, for MgCO₃ (c), $Q_f = 268.1$ and 265.1 , respectively.

MgCO₃ · nH₂O (c). We have estimated the value for the monohydrate. Takahashi and Nukada¹ reported $Q^s = 4.26$ for the reaction, $\text{MgCO}_3 \cdot \text{H}_2\text{O} \text{ (c)} + 2 \text{H}_2\text{O} \text{ (liq.)} = \text{MgCO}_3 \cdot 3 \text{H}_2\text{O} \text{ (c)}$.

Mg(C₂H₃O₃)₂ (aq.). deForcrand³ measured the heat of reaction of MgSO₄ (aq.) with aqueous barium glycollate and aqueous lead glycollate to be 2.65 and 1.12, respectively.

Mg(C₂H₃O₃)₂ · nH₂O (c). deForcrand³ measured the heats of solution of anhydrous magnesium glycollate and of the dihydrate.

MgCl₂ · 6 CH₃OH (c). Lloyd, Brown, Bonnell, and Jones¹ reported dissociation pressure data on this alcoholate.

Mg(NO₃)₂ · 6 CH₃OH (c). Lloyd, Brown, Bonnell, and Jones¹ reported dissociation pressure data on this alcoholate.

MgCN₂ (c). Franc and Hockward¹ measured the heat of combustion of magnesium cyanamide.

Mg(CN)₂ (aq.). Varet³ measured the heat of reaction of MgSO₄ (aq.) with Ba(CN)₂ (aq.).

MgSiO₃ (c). Tschernobaeff¹ reported the heat of reaction of MgCO₃ (c) with SiO₂ (c). See also Marchal¹ and White.¹

MgZn₂ (c). Roos² measured the heat of solution of this alloy in bromine water to be 322.1; Biltz and Hohorst¹ found the value 167.6 in HCl(8). See also von Wartenberg.⁸

Mg₂Sn (c). For the heat of solution of this alloy, Biltz and Holverscheidt¹ reported 261 in (FeCl₃+HCl) (aq.). This value was later corrected to 251 by Biltz and Meyer.²

MgCd (c, II). For the heat of solution of this alloy, Roos² found 223.5 in bromine water; Biltz and Hohorst¹ found 123.7 in HCl (8).

MgCd (c, I). Roos² reported a value for the heat of transition at 243°.

MgHg₄ (c). Tammann and Ohler¹ measured the heat of solution of this alloy in HCl (9.3) to be 95.8.

Mg₄Al₃ (c). For the heat of solution of this alloy, Roos² found 111.7 in bromine water; Biltz and Hohorst¹ 779 in HCl (8).

Mg_nCe (c). Biltz and Pieper¹ reported the following heats of solution in HCl (20): MgCe (c), 260.5; Mg₃Ce (c), 477.3. See also Muthmann and Beck.¹

MgBr₂ · nHgBr₂ (aq.). Varet^{2, 6} measured the heats of mixing MgBr₂ (aq.) with $\frac{1}{2}$, 1, and 2 moles of HgBr₂ (aq.).

Mg(CN)₂ · nHg(CN)₂ (aq.). Varet^{2, 6} measured the heats of mixing Mg(CN)₂ (aq.) with 1 and 2 moles of Hg(CN)₂ (aq.).

HgX₂ · 2Hg(CN)₂ (aq.). Varet^{2, 6} measured the heats of mixing 2Hg(CN)₂ (aq.) with HgCl₂ (aq.), HgBr₂ (aq.), and HgI₂ (aq.), respectively.

HgX₂ · 2Hg(CN)₂ · nH₂O (c). Varet^{2, 6} measured the heats of solution of the chloride hexahydrate and the bromide and iodide octahydrates.

MgWO₄ (c). Tammann and Westerholt¹ reported $Q=3.4$ for the reaction of MgO (c) with WO₃ (c).

MgMoO₄ (c). Tammann and Westerholt¹ reported $Q=7.3$ for the reaction of MgO (c) with MoO₃ (c).

6MgO · 8B₂O₃ · MgCl₂ (c). For the heat of transition of boracite at 265°, Kroker¹ found -0.84, Mallard and LeChatelier¹ found -1.8.

CALCIUM

Ca (c, II). Standard state.

Ca (c, I). Eastman, Williams, and Young¹ and Zalesenski and Zulenski¹ reported values for the transition at 400°.

Ca (liq.). Data on the heat of fusion of calcium were reported by Randall and Tamale,¹ Moldenhauer and Roll-Hansen,¹ Bronsted,² and Zalesenski and Zulenski.¹

Ca (g). Vapor pressure data on solid and liquid calcium were reported by Pilling,¹ Ruff and Hartman,¹ and Hartman and Schneider.¹ See also Randall and Tamale.¹ The values for the energy states of gaseous monatomic calcium are from Fowler¹ and Bowen.⁵

CaCl₂ (aq.). The data on the heat of solution of calcium in aqueous hydrochloric acid are: Guntz and Benoit,^{1,2} 129.8 in HCl(120) at 16°; Guntz and Bassett,^{1,2} 129.0 in HCl(120) at 9°; Biltz and Hohorst,¹ 130.1 in HCl(8). See also Thomsen,¹⁵ Moissan,^{1,2} Bronsted,² and Copeaux and Phillips.¹ Data on the heat of dilution of aqueous CaCl₂ were reported by Thomsen,¹⁵ Tucker,¹ Dunnington and Hoggard,¹ Lehtonen,¹ Nernst and Orthmann,² Richards and Dole,¹ and Lange and Streeck.¹

Ca⁺⁺ (∞). This value is obtained from those for CaCl₂ (∞) and Cl⁻ (∞).

CaO (c). The data on the heat of solution of calcium oxide in aqueous hydrochloric acid are: Bäckstrom,¹ 46.17 in HCl(55) at 25°; Berthelot,²² 46.1 in HCl(330) at 16°; Matignon,⁴ 47.0 in HCl(110); Thorvaldson, Brown, and Peaker,¹ 46.46 in HCl(200) at 20°; Copeaux and Phillips,¹ 46.1 in HCl(25); Thomsen,¹⁵ 46.03 in HCl(200). Gautier's¹ values for the fused oxide and the oxide prepared at 1000°, 1200°, and 2000° are 46.54, 46.47, 46.40, and 46.51, respectively, in HCl(110).

CaO (g). Vapor pressure data were reported by Ruff and Schmidt¹ and Claasen and Veenemans.¹

CaO (liq.). Washburn¹ reported the heat of fusion.

Ca(OH)₂ (aq.). Moissan^{1,2} and Guntz and Bassett² measured the heat of solution of calcium in water. The heat of neutralization of Ca(OH)₂ (aq.) with 2HCl (aq.) was measured by Thomsen,¹⁵ Berthelot,²² de Forcrand,²⁹ and Hess.⁵

Ca(OH)₂ (c). For the heat of solution of Ca(OH)₂ (c), Thomsen¹⁵ found 30.49 in HCl(200), and Thorvaldson and Brown¹ found 30.82 in HCl(200) at 20°. See also Berthelot.²² Direct measurements of the heat of the reaction, CaO (c) + H₂O (liq.) = Ca(OH)₂ (c), were made by Mannheimer,¹ Kohnert,¹ and Kohlschutter and Feilknecht,¹ who reported $Q = 15.30, 15.18, \text{ and } 15.30$, respectively.

CaO₂ (c). Bergius,¹ from equilibrium studies, reported $Q = -5.4$ for the reaction, CaO₂ (c) = CaO (c) + $\frac{1}{2}$ O₂ (g). de Forcrand^{29, 30} measured the heat of solution of CaO₂ (c) in HCl(100) to be 18.93.

CaO₂ · 8H₂O (c). de Forcrand^{29, 30} reported $Q = 15.6$ for the reaction, CaO₂ (c) + 8H₂O (liq.) = CaO₂ · 8H₂O (c).

CaH₂ (c). Guntz and Bassett¹ and Bronsted² measured the heat of solution of solid calcium hydride in aqueous HCl. Equilibrium data on the reaction, CaH₂ (c) = Ca (c) + H₂ (g), were obtained by Brönsted² and Moldenhausser and Roll-Hansen,¹ and were reviewed by Lewis and Randall.⁵ See also Kassarnowsky.²

CaH (g). Watson² reported, from spectroscopic data, the energy of dissociation into gaseous atoms. See also Hulthen.¹

Ca(OH)₂ · H₂O₂ (c). de Forcrand^{29, 30} measured the heat of reaction of Ca(OH)₂ (aq.) with H₂O₂ (aq.) to be 6.85.

CaF₂ (c). Guntz¹ measured the heat of reaction of Ca(OH)₂ (aq.) with 2HF (aq.) to form CaF₂ (c) and 2H₂O (liq.).

CaF₂ (∞). This value is obtained from those for the aqueous ions.

CaF (g). Johnson³ reported the energy of dissociation into gaseous atoms.

CaCl (c). Benoit² reported the value 72.2 for the heat of solution of CaCl (c) in aqueous HCl; which yields $Q_f = 96.9$. Since the mixture $\frac{1}{2}$ CaCl₂ (c) + $\frac{1}{2}$ Ca (c) would have a heat of formation of 95.3, the existence of the subchloride, CaCl (c), appears doubtful.

CaCl₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 17.41₂₀₀; Person,⁶ 19.4; Ditte,¹⁰ 15.0; Baud,¹ 18.17₄₀₀¹⁶; Pickering,⁸ 18.73₄₀₀; Berthelot and Ilosvay,¹ 17.6₁₀₀¹²; Lehtonen,¹ 16.05₂₀₀⁰; de Forcrand,⁵⁷ 17.47¹⁵. See also Cambi and Devoto,¹ Lorenz and Winzer,¹ Jones and Taylor,¹ Fajans,³ and Favre and Silbermann.³

CaCl₂ · H₂O (c). The data on the heat of solution are: Thomsen,¹⁵ 12.1₁₀₀; Sabatier,² 11.7₃₀₀²¹.

CaCl₂ · 2H₂O (c). Thomsen¹⁵ measured the heat of solution.

CaCl₂ · 4H₂O (c). Thomsen¹⁵ measured the heat of solution.

CaCl₂ · 6H₂O (c). The data on the heat of solution are: Thomsen,¹⁵ -4.36₄₀₀; Pickering,⁸ -4.25₄₀₀; Ditte,¹⁰ -4.5¹²; van Deventer and van der Stadt,¹ -4.56. See also van't Hoff, Kenrick, and Dawson.¹

CaCl₂ · 6H₂O (liq.). Morgan and Benson¹ reported the heat of fusion of the hexahydrate to be 8.93.

CaCl₂ · 2CaO (c). Andre^{1, 2} measured the heat of solution in HCl (aq.).

CaCl₂ · 3CaO · *n*H₂O (c). Andre^{1, 2} measured the heats of solution of the anhydrous basic chloride and of the tri- and hexadecahydrates in HCl (aq.). See also Tassilly.¹

Ca(ClO)₂ (aq.). Neumann and Muller¹ measured the heat of reaction of Ca(OH)₂ (aq.) with HClO (aq.) and with Cl₂ (g).

CaOCl₂ (aq.). Ochi^{2, 3, 4} measured the heat of the reaction of CaOCl₂ (aq.) with H₂O₂ (aq.).

CaOCl₂ (c). Ochi^{2, 3, 4} measured the heat of solution. Neumann and Muller,¹ Hurter,¹ and Nydegger¹ measured the heat of reaction of CaO (c) with Cl₂ (g).

CaOCl₂ · H₂O (c). Ochi^{2, 3, 4} measured the heat of solution.

CaBr₂ (aq.). The value for CaBr₂ (∞) is obtained from those for Ca⁺⁺(∞) and Br⁻(∞). Data on the heat of dilution were reported by Lange and Streeck.¹

CaBr₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 24.5₄₀₀; Varet,² 26.4₄₀₀¹⁵; Pickering,⁸ 23.3₈₀₀. See also Cambi and Devoto.¹

CaBr₂ · 6H₂O (c). Thomsen¹⁵ measured the heat of solution.

CaBr₂ · 3CaO · *n*H₂O (c). Tassilly^{1, 2} measured the heats of solution of the tri- and hexadecahydrates in aqueous HBr.

CaI₂ (aq.). The value for CaI₂ (∞) is obtained from those for Ca⁺⁺(∞) and I⁻(∞). We have estimated the heat of dilution.

CaI₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 27.70₄₀₀; de Forcrand,⁵⁷ 28.1₂₀₀¹⁵; Varet,² 27.6; Pickering,⁸ 26.9₈₀₀.

CaI₂ · 8H₂O (c). Tassilly^{1, 4} measured the heat of solution.

CaI₂ · 3CaO · 16H₂O (c). Tassilly¹ measured the heat of solution.

CaS (aq.). This value is obtained from those for the ions.

CaS (c). Sabatier¹ measured the heat of solution in aqueous HCl. See also Taylor¹ and Sherman.¹

CaSO₃ · 2H₂O (c). Bichowsky⁴ reported $Q=6.3$ for the reaction, CaS₂O₃ (aq.) + 2H₂O (liq.) = CaSO₃ · 2H₂O (c) + S (c).

CaS₂O₃ (aq.). The value for CaS₂O₃ (800) is obtained from those for the ions. Data on the heat of dilution were reported by Bichowsky.⁴

CaSO₄ (aq.). The value for CaSO₄ (∞) is obtained from those for Ca⁺⁺(∞) and SO₄⁻⁻(∞). Thomsen¹⁵ measured the heat of neutralization of H₂SO₄ (aq.) with Ca(OH)₂ (aq.). See also Hess.⁵ Data on the heat of dilution were reported by Lange and Messner² and Lange and Streeck.²

CaSO₄ · nH₂O (c). For the heat of solution of the dihydrate Thomsen¹⁵ and Lange and Dürr¹ found -0.30 and -0.84₄₀₀₀, respectively. Values for the heats of hydration of CaSO₄ (c, anhydrite), CaSO₄ (c, "soluble"), and the hemihydrate to the dihydrate were reported by Thomsen,¹⁵ van't Hoff, Armstrong, Henrickson, Weigert, and Just,¹ Chassevent,¹ Mixter,¹⁷ and de Forcrand.¹⁴

CaSe (c). Fabre¹ measured the heat of solution in aqueous HCl.

CaN₆ (c). Wohler and Martin¹ measured the heat of decomposition of calcium azide.

Ca₃N₂ (c). For the heat of solution of calcium nitride, Moser and Herzner¹ reported 261.6 and Guntz and Bassett^{1, 2} reported 342.7. From measurement of the direct formation, Franck and Bodea¹ reported $Q_f = 102.6$.

CaN₂O₂ · 4H₂O (c). Berthelot¹⁰⁷ measured the heat of reaction of this tetrahydrate with aqueous (Br₂ + KBr).

Ca(NO₃)₂ (aq.). The value for Ca(NO₃)₂ (∞) is obtained from those for Ca⁺⁺(∞) and NO₃⁻(∞). Data on the heat of dilution were reported by Partington and Soper,¹ Nernst and Orthmann,² Rümelin,¹ Lange and Messner,² and Lange and Streeck.²

Ca(NO₃)₂ (c). The data on the heat of solution yield the following values for S_{400} : Thomsen,¹⁵ 3.94; Pickering,⁸ 3.94; Berthelot,¹³¹ 3.2; Ewing, Rogers, Miller, and McGovern,¹ 3.96; Partington and Soper,¹ 3.92.

Ca(NO₃)₂ · nH₂O (c). The data on the heat of solution of the tetrahydrate yield the following values for S_{400} : Thomsen,¹⁵ -7.25; Pickering,⁸ -8.35; Ewing, Rogers, Miller, and McGovern,¹ -8.13; Berthelot,¹³¹ -7.6. The data of Ewing, Rogers, Miller, and McGovern¹ yield the following values for S_{400} : trihydrate, -4.32; dihydrate, -3.35. Dissociation pressure data were reported by Lescoeur,⁴ Ewing,¹ and Biltz.⁸

$\text{Ca}(\text{NO}_3)_2 \cdot 4\text{H}_2\text{O}$ (liq.). Data on the heat of fusion of the tetrahydrate were reported by Pickering⁸ and Morgan and Owen.¹

$\text{Ca}(\text{NO}_3)_2(\text{C}_2\text{H}_5\text{OH})$. For the heat of solution of calcium nitrate in ethyl alcohol, Partington and Soper found 7.41₂₀₀ $\text{C}_2\text{H}_5\text{OH}$ ²⁵. See also Pickering.⁸

$\text{Ca}(\text{NH}_2)_2$ (c). Guntz and Benoit¹ measured the heat of solution of calcium amide in aqueous HCl.

$\text{Ca}(\text{NO}_3)_2 \cdot \text{Ca}(\text{OH})_2 \cdot n\text{H}_2\text{O}$ (c). Werner¹ measured the heat of solution in aqueous HNO_3 of the anhydrous compound and of the hydrate with $2\frac{1}{2}$ H_2O .

$\text{CaX}_2 \cdot n\text{NH}_3$ (c). Hüttig¹ and Biltz, Klatte, and Rahlfs¹ reported values for the heats of dissociation of the mono-, di-, tetra-, and octammines of CaCl_2 and the mono-, di-, hexa-, and octammines of CaBr_2 and CaI_2 ; Ephraim⁹ for the octammine of CaCl_2 ; Bonnefoi¹ for the di- and octammines of CaCl_2 and the hexammine of CaI_2 ; Isambert^{2, 5} for the di-, tetra-, and octammines of CaCl_2 . See also Isambert¹³ and Antoine.³

$\text{CaSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot \text{H}_2\text{O}$ (c). Barre¹ measured the heat of solution.

$2\text{CaSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4$ (c). Barre¹ measured the heat of solution.

$5\text{CaSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \cdot \text{H}_2\text{O}$ (c). Barre¹ measured the heat of solution.

$\text{Ca}_3(\text{PO}_4)_2$ (colloidal). Berthelot^{52, 54} measured the heat of reaction of H_3PO_4 (aq.) with $1\frac{1}{2}$ $\text{Ca}(\text{OH})_2$ (aq.) to be 29.2.

$\text{Ca}_3(\text{PO}_4)_2$ (c). Berthelot^{52, 54} measured the heat of reaction of $1\frac{1}{2}$ CaCl_2 (aq.) with Na_3PO_4 (aq.).

CaHPO_4 (aq.). Berthelot^{52, 54} measured the heat of reaction of H_3PO_4 (aq.) with $\text{Ca}(\text{OH})_2$ (aq.) to be 24.5.

$\text{Ca}(\text{H}_2\text{PO}_4)_2$ (aq.). Berthelot^{52, 54} measured the heat of reaction of H_3PO_4 (aq.) with $\frac{1}{2}$ $\text{Ca}(\text{OH})_2$ (aq.) to be 14.8.

$\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ (c). Joly^{3, 4} reported $Q=2.9$ for the reaction, Na_2HPO_4 (aq.) + $2\text{H}_2\text{O}$ (liq.) + CaCl_2 (aq.) = $\text{CaHPO}_4 \cdot 2\text{H}_2\text{O}$ (c) + 2NaCl (aq.).

$\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O}$ (c). We have estimated this value.

$\text{Ca}(\text{H}_2\text{PO}_4)_2 \cdot \text{H}_2\text{O} \cdot n\text{NH}_3$ (c). Stollenwerk¹ reported dissociation pressure data on the tetra-, di-, and monammines.

$\text{Ca}_3(\text{AsO}_4)_2$ (c, ppt.). Blarez¹ measured the heat of reaction of H_3AsO_4 (aq.) with $1\frac{1}{2}$ $\text{Ca}(\text{OH})_2$ (aq.) to be 29.5.

CaHAsO_4 (aq.). Blarez¹ measured the heat of reaction of H_3AsO_4 (aq.) with $\text{Ca}(\text{OH})_2$ (aq.) to be 27.0.

$\text{Ca}(\text{H}_2\text{AsO}_4)_2$ (aq.). Blarez¹ measured the heat of reaction of H_3AsO_4 (aq.) with $\frac{1}{2}$ $\text{Ca}(\text{OH})_2$ (aq.) to be 14.5.

CaC_2 (c). The data on the heat of solution of calcium carbide in dilute aqueous HCl are: de Forcrand,²¹ 58.25¹³; Ruff and Josephy,¹ 60.8 in HCl(100). Guntz and Bassett¹ reported $Q_f=13.1$. Dissociation pressure data were reported by Ruff and Forster,¹ Krase and Yee,¹ and Franck and Hochwald.¹

CaCO_3 (c, calcite). Thomsen¹⁵ and Berthelot¹² measured the heat of

reaction of CaCl_2 (aq.) with Na_2CO_3 (aq.). Berthelot¹⁵ measured the heat of solution of calcite in aqueous nitric acid. Bäckstrom¹ measured the heat of solution of calcite in HCl (50), saturated with CO_2 , to be 3.24 at 25°. The heat of the direct reaction of lime with carbon dioxide was measured by Favre and Silbermann² and Dragert.¹ See also Franck and Hochwald¹ and Le Chatelier.⁷ Dissociation pressure data were reported by Andrussow,² Smyth and Adams,¹ Lebeau,¹ Zavrieff,¹ Pott,¹ Reisenfeld,¹ Dutoit,¹ and Johnston.^{2, 5} See also Bäckstrom.¹

CaCO_3 (c, aragonite). For the heat of transition of aragonite to calcite the following values were reported: Favre and Silbermann,² 2.4; LeChatelier,⁷ -0.3; Laschtschenko,⁵ -2.7; Bäckstrom,⁴ -0.33; Bäckstrom,⁵ -0.04.

$\text{Ca}(\text{HCO}_3)_2$ (aq.). Randall and White³ reviewed the data of Bäckstrom,³ Cameron and Brezeate,¹ Cameron and Robinson,^{1, 2} Cavazzi,¹ Ehlert and Hempel,¹ Engel,¹ Haehnel,^{1, 2} Johnston,³ Kendall,² McCoy and Smith,¹ Schloesing,¹ Wells,¹ and Frear, Johnston, and Kline,¹ on the solubility of calcium carbonate in aqueous carbonic acid, and concluded that $Q^{25} = 8.6$ for the reaction, CaCO_3 (c, calcite) + CO_2 (g) + H_2O (liq.) = $\text{Ca}(\text{HCO}_3)_2$ (aq.).

CaC_2O_4 (c). Berthelot¹² found $Q = 8.1^{15}$ for the reaction, $\text{K}_2\text{C}_2\text{O}_4$ (200) + CaCl_2 (200) = CaC_2O_4 (c) + 2KCl (200).

$\text{Ca}(\text{CHO}_2)_2$ (aq.). Berthelot^{9, 131} measured the heat of neutralization of aqueous formic acid with aqueous calcium hydroxide.

$\text{Ca}(\text{CHO}_2)_2$ (c). Berthelot^{9, 131} measured the heat of solution of calcium formate.

$\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$ (aq.). The value for calcium acetate at infinite dilution has been obtained from those for the aqueous ions. Berthelot⁹ measured the heat of neutralization of aqueous acetic acid with aqueous calcium hydroxide.

$\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Berthelot⁹ and Favre and Silbermann³ measured the heat of solution.

$\text{Ca}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \text{H}_2\text{O}$ (c). Berthelot⁹ measured the heat of solution.

$\text{Ca}(\text{C}_2\text{H}_3\text{O}_3)_2$ (aq.). This value is obtained from those for the aqueous calcium and glycolate ions.

$\text{Ca}(\text{C}_2\text{H}_3\text{O}_3)_2 \cdot n\text{H}_2\text{O}$ (c). de Forcrand³ measured the heats of solution of the anhydrous salt and the tri- and pentahydrates.

$\text{Ca}(\text{C}_2\text{H}_5\text{O})_2$ (c). de Forcrand^{13, 22} measured the heat of solution in HCl (110).

$\text{Ca}(\text{C}_2\text{H}_5\text{O})_2 \cdot 2\text{C}_2\text{H}_5\text{OH}$ (c). de Forcrand^{13, 22} measured the heat of solution in HCl (110).

$3\text{CaO} \cdot 4\text{C}_2\text{H}_5\text{OH}$ (c). de Forcrand^{13, 22} measured the heat of solution in aqueous HCl .

$\text{CaX}_2 \cdot n\text{C}_2\text{H}_5\text{OH}$ (c). Bonnell and Jones¹ reported dissociation pressure data on the tri- and tetra-alcoholates of CaCl_2 and CaBr_2 .

$\text{CaCl}_2 \cdot (\text{CH}_3)_2\text{CO}$ (c). Bagster¹ obtained dissociation pressure data on this compound.

$\text{Ca}(\text{NO}_3)_2 \cdot 2\text{CH}_3\text{OH}$ (c). Lloyd, Brown, Bonnell, and Jones¹ reported dissociation pressure data on this compound.

$\text{Ca}(\text{CN})_2$ (aq.). Joannis¹ measured the heat of neutralization of aqueous calcium hydroxide with aqueous HCN.

$3\text{CaO} \cdot \text{Ca}(\text{CN})_2 \cdot 15\text{H}_2\text{O}$ (c). Joannis¹ measured the heat of solution in aqueous HCl.

CaCN_2 (c). Franck and Hochwald¹ and Krase and Yee¹ measured the heat of the reaction, CaC_2 (c) + N_2 (g) = CaCN_2 (c) + C (c), to be 72 and 98, respectively; whence, for CaCN_2 (c), $Q_f = 86.5$ and 112.5. The equilibrium data of Franck and Heimann¹ on the same reaction yield, for CaCN_2 (c), $Q_f = 85.9$. See also Thompson and Lombard² and Dotch.¹ The average of the data of Franck and Hochwald,¹ Kameyama and Oka,² and Kameyama¹ on the heat of combustion of CaCN_2 (c) yield, for the latter, $Q_f = 84.5$. The data of Krase and Yee¹ on the reaction, Ca_3N_2 (c) + 3C (c) + 2N_2 (g) = 3CaCN_2 (c), yield, for CaCN_2 (c), $Q_f = 102$. See also Cochet,¹ Badger,¹ LeBlanc and Eschmann,¹ Matignon,⁹ and Landis.¹

CaSi_n (c). Wohler and Martin¹ measured the heats of combustion of CaSi (c) and CaSi_2 (c) to form CaSiO_3 (c) and CaSiO_3 (c) + SiO_2 (c), respectively.

CaSiO_3 (c). Tschernobaeff¹ and Tschernobaeff and Wologdine¹ reported $Q = -25.3$ for the reaction, CaCO_3 (c) + SiO_2 (c) = CaSiO_3 (c) + CO_2 (g); whence, for CaSiO_3 (c), $Q_f = 373.1$. For the same reaction, LeChatelier^{8, 10} reported $Q = -13.4$; whence, for CaSiO_3 (c), $Q_f = 385$. For the heat of solution of CaSiO_3 (c) in HCl (24.65) at 50°, Roth and Chall¹ found $Q = 23.04$, and for the reaction, CaO (c) + SiO_2 (c, α quartz) = CaSiO_3 (c), reported $Q^{50} = 19.66$; whence, for CaSiO_3 (c), $Q_f = 374.7$. The equilibrium data of Marchal⁶ on the reaction, CaSO_4 (c) + SiO_2 (c) = CaSiO_3 (c) + SO_3 (g), yield $Q = -81.2$; whence, for CaSiO_3 (c), $Q_f = 369$. Wagner's¹ data on the heats of solution, in HCl (25), of the two forms of CaSiO_3 (c), wollastonite and pseudowollastonite, $Q = 20.01$ and 21.27, respectively, yield for the latter, $Q_f = 376.6$, and for the transition of the former into the latter, $T = -1.26$. See Allen, White, and Wright.¹

Ca_2SiO_4 (c). Tschernobaeff¹ and Tschernobaeff and Wologdine¹ reported $Q = -56.7$ for the reaction, 2CaCO_3 (c) + SiO_2 (c) = Ca_2SiO_4 (glass) + 2CO_2 (g), whence, for Ca_2SiO_4 (c), $Q_f = 536.7$.

CaSn_3 (c). Biltz and Meyer¹ measured the heat of solution of this alloy in aqueous ($\text{FeCl}_3 + \text{HCl}$) to be 273. See also Biltz and Holverschelt.¹

$\text{CaI}_2 \cdot 2\text{PbI}_2 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous double salt and of the heptahydrate.

CaZn_n (c). Roos² measured the heats of solution of CaZn_{10} (c) and CaZn_4 (c) in bromine water to be 890.3 and 487.8, respectively. Biltz and Wagner¹ measured the heats of solution of CaZn_{10} (c), CaZn_4 (c), Ca_2Zn_3 (c), and Ca_4Zn (c) in HCl (20) to be 381.0, 219.5, 307.8, and 512.0, respectively.

CaCd₃ (c). Roos² measured the heat of solution of this alloy in HCl(8).

CaBr₂ · nHgBr₂ (aq.). Varet^{2, 6} measured the heats of mixing CaBr₂ (aq.) with 1 and 2 HgBr₂ (aq.), respectively.

Ca(CN)₂ · nHg(CN)₂ (aq.). Varet^{2, 6} measured the heats of mixing Ca(CN)₂ (aq.) with 1 and 2 Hg(CN)₂ (aq.), respectively.

CaX₂ · 2 Hg(CN)₂ (aq.). Varet^{2, 6} measured the heats of mixing 2 Hg(CN)₂ (aq.) with CaCl₂ (aq.), CaBr₂ (aq.), and CaI₂ (aq.), respectively.

CaX₂ · 2 Hg(CN)₂ · nH₂O (c). Varet^{2, 6} measured the heats of solution of the chloride hexahydrate, the bromide heptahydrate, and the iodide hexahydrate.

Ca(CN)₂ · nAgCN (aq.). Varet⁵ measured the heats of mixing Ca(CN)₂ (aq.) with 1 and 2 AgCN (c), respectively.

CaO · Fe₂O₃ (c). The equilibrium data of Marchal⁶ yield $Q = -46$ for the reaction, Fe₂O₃ (c) + CaSO₄ (c) = CaO · Fe₂O₃ (c) + SO₃ (g); whence, for CaO · Fe₂O₃ (c), $Q_f = 399$.

Ca₂Fe(CN)₆ (aq.). Joannis¹ measured the heat of reaction of H₄Fe(CN)₆ (aq.) with 2 Ca(OH)₂ (aq.) to be 56.4.

CaH₂Fe(CN)₆ (aq.). Joannis¹ measured the heat of reaction of H₄Fe(CN)₆ (aq.) with Ca(OH)₂ (aq.) to be 28.4.

Ca₂Fe(CN)₆ · 12 H₂O (c). Joannis¹ measured the heat of solution.

CaWO₄ (c). Tammann and Westerholt¹ calculated $Q = 39.8$ for the reaction, CaO (c) + WO₃ (c) = CaWO₄ (c).

CaO · nB₂O₃ (c). Griveau¹ measured the heats of solution in aqueous HCl of these borates with $n = \frac{1}{3}, \frac{1}{2}, 1$, and 2.

CaAl₃ (c). Biltz and Wagner¹ measured the heat of solution of this alloy in HCl(8) to be 454.

nCaO · Al₂O₃ (gls.). Tschernobaeff¹ reported $Q = 44.7, 87.0$, and 132.5 for the heats of the reactions of Al₂O₃ (c) with 1, 2, and 3 CaCO₃ (c), respectively.

3 CaCl₂ · 4 AlCl₃ (c). Baud¹ measured the heat of solution.

3 CaO · Al₂O₃ · 2 SiO₂ (c). Tschernobaeff and Wologdine¹ reported $Q = 50.2$ for the reaction, 2 SiO₂ (c) + Al₂O₃ (c) + 3 CaO (c) = 3 CaO · Al₂O₃ · 2 SiO₂ (c).

CaO · Al₂O₃ · 6 SiO₂ (c, heulandite). Tschernobaeff and Wologdine¹ measured the heat of solution in aqueous (20%) HF.

Ca₃Mg₄ (c). Biltz and Hohorst¹ measured the heat of solution of this alloy in HCl(8). See also Roos.²

CaCl₂ · 2 MgCl₂ · 2 H₂O (c). van't Hoff, Kenrick, and Dawson¹ measured the heat of solution.

CaCO₃ · MgCO₃ (c). Mitchell¹ found the heat of solution of dolomite in aqueous HCl to be 31.6. Bäckstrom² calculated, from the equilibrium data of Marc and Limek,¹ $Q = 1.8$ for the reaction, CaCO₃ (c) + MgCO₃ (c) = CaCO₃ · MgCO₃ (c).

STRONTIUM

Sr (c). Standard state.

Sr (g). Vapor pressure data were reported by Ruff and Hartmann¹ and Hartmann and Schneider.¹ We have estimated the value for the heat of sublimation from the latter data. The values for the energy states of gaseous monatomic strontium are from Hansen and Thorsen,¹ Saunders,² Russell and Saunders,¹ and Fowler.¹

Sr (liq.). We have estimated the heat of fusion of strontium.

SrCl₂ (aq.). The data of Guntz and Benoit² yield for the heat of the reaction, $\text{Sr (c)} + 2 \text{HCl(140)} = \text{SrCl}_2(280) + \text{H}_2(\text{g})$, $Q = 130.1$; whence, for $\text{SrCl}_2(200)$, $Q_f = 209.0$. Similar data on less pure samples of strontium were obtained by Thomsen¹⁵ and Guntz and Roderer.¹ Data on the heat of dilution of aqueous strontium chloride were reported by Stearn and Smith,¹ Lehtonen,¹ Pratt,¹ Magie,¹ Dunnington and Hoggard,¹ and Lange and Streeck.¹

Sr⁺⁺ (∞). This value is obtained from those for $\text{SrCl}_2(\infty)$ and $\text{Cl}^-(\infty)$.

SrCl₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 11.15₄₀₀; Berthelot,⁷ 11.0; Berthelot and Ilosvay,¹ 11.1¹⁵; Baud,¹ 11.4₄₄₀²¹; Pickering,⁷ 11.27₂₀₀; Benoit,² 10.42_{HCl(aq.)}¹⁵; Maier² (see Hüttig and Slonim¹), 11.44₄₀₀¹⁷. See also Cambi and Devoto.¹

SrO (c). Thomsen¹⁵ measured the heat of solution of strontium oxide in 2 HCl(200) to be 56.97; whence, for SrO (c) , $Q_f = 141.5$. For the heat of solution of SrO (c) in water, Berthelot²² reported 27.2 and de Forcrand⁴⁸ reported 29.7, 28.3, and 30.8. These values yield for SrO (c) , $Q_f = 143.6$, 141.1, 142.5, and 140.0, respectively.

SrO (g). We have estimated the heat of sublimation from the vapor pressure data of Tiede and Birnbauer.¹

Sr(OH)₂ (aq.). Thomsen,¹⁵ de Forcrand,²⁸ and Berthelot²² measured the heat of neutralization of 2 HCl (aq.) with $\text{Sr(OH)}_2(\text{aq.})$.

Sr(OH)₂ (c). The data on the heat of solution of solid strontium hydroxide are: Thomsen,¹⁵ 11.64₄₀₀; Berthelot,⁹ 9.6; Berthelot,²² 37.68_{2HCl(330)}¹⁶; de Forcrand,⁵¹ 10.33₁₁₀₀¹⁵. See also Johnston^{1, 4} and Jorissen.¹

Sr(OH)₂ · H₂O (c). de Forcrand⁵¹ measured the heat of solution.

Sr(OH)₂ · 8 H₂O (c). The data on the heat of solution are: de Forcrand,⁵¹ -14.27₁₁₀₀¹⁵; Thomsen,¹⁵ 12.99_{2HCl(200)}; Berthelot,²² 12.96_{2HCl(330)}¹⁶. See also Muller and Erzbach¹ and Lescoeur.²

SrO₂ (c). de Forcrand²⁸ measured the heat of solution in aqueous HCl.

SrO₂ · 9 H₂O (c). de Forcrand²⁸ measured the heat of solution in aqueous HCl.

Sr₂O (c). Benoit² measured the heat of solution in aqueous HCl.

SrH₂ (c). Guntz and Benoit¹ measured the heat of solution in aqueous HCl. See also Kassarnowsky.²

SrF₂ (c). Petersen³ measured the heat of reaction of 2 AgF (aq.) with SrCl₂ (aq.) to be 34.5. Guntz¹ measured the heat of neutralization of 2 HF (aq.) with Sr(OH)₂ (aq.) to be 17.9.

SrF (g). Johnson³ estimated the energy of dissociation into gaseous atoms, from spectroscopic data.

SrCl (c). Benoit² reported the heat of solution in aqueous HCl for this supposed subchloride.

SrCl₂ · H₂O (c). Maier² (see Hüttig and Slonim¹) measured the heat of solution to be 6.02₄₀₀¹⁷; Thomsen¹⁵ found 5.88₄₀₀.

SrCl₂ · 2 H₂O (c). The data on the heat of solution in 400H₂O are: Maier² (see Hüttig and Slonim¹), 2.57; Sabatier,² 2.07; Pickering,⁷ 1.92; Thomsen,¹⁵ 2.08.

SrCl₂ · 6 H₂O (c). The data on the heat of solution yield the following values for *S*₄₀₀: Thomsen,¹⁵ -7.50; Berthelot,⁷ -7.3; Maier² (see Hüttig and Slonim¹), -7.44. See also Favre and Silbermann.³ Dissociation pressure data on the hexahydrate were reported by Schumb,¹ Hüttig and Slonim,¹ Andreae,¹ Frowein,¹ Cohen,⁴ Schottky,¹ Linebarger,¹ Lescoeur,² Schumb,¹ Baxter and Lansing,¹ Menzies,² and Biltz.⁸

Sr(ClO)₂ (aq.). Neumann and Muller² measured the heat of reaction of Sr(OH)₂ (aq.) with Cl₂ (g) and with 2 HClO (aq.).

SrCl₂ · SrO · *n*H₂O (c). Andre¹ measured the heats of solution of the mono- and nonahydrates.

SrBr₂ (aq.). The value for SrBr₂ (∞) is obtained from those for the aqueous ions. Data on the heat of dilution were reported by Lange and Streeck.¹

SrBr₂ (c). The data on the heat of solution are: Thomsen,¹⁵ 16.1₄₀₀; Tassilly,¹ 16.0₂₀²⁰; Maier² (see Hüttig and Slonim¹), 16.25.¹⁹ See also Favre and Valson² and Cambi and Devoto.¹

SrBr₂ · H₂O (c). The data on the heat of solution yield the following values for *S*₄₀₀: Thomsen,¹⁵ 9.90; Maier² (see Hüttig and Slonim¹), 8.86.

SrBr₂ · 2 H₂O (c). Thomsen¹⁵ measured the heat of solution.

SrBr₂ · 4 H₂O (c). Thomsen¹⁵ measured the heat of solution.

SrBr₂ · 6 H₂O (c). The existing data yield the following values for *S*₄₀₀: Thomsen,¹⁵ -6.45; Maier² (see Hüttig and Slonim¹), -7.11. Dissociation pressure data on the hexahydrate were reported by Trip,¹ Hüttig and Slonim,¹ and Lescoeur.²

SrBr₂ · SrO · *n*H₂O (c). Tassilly¹ measured the heats of solution of the tri- and nonahydrates in aqueous HBr.

SrI₂ (aq.). The value for SrI₂ (∞) is obtained from those for the aqueous ions. We have estimated the heat of dilution of aqueous strontium iodide.

SrI₂ (c). For the heat of solution, Tassilly¹ found 20.5 and Maier² (see Slonim and Hüttig¹) 20.6¹⁹.

SrI₂ · *n*H₂O (c). Maier² (see Slonim and Hüttig¹) measured the heats of solution of the mono-, di-, and hexahydrates. See also Tassilly.^{1, 4}

Dissociation pressure data were reported by Trip¹ and Hüttig and Slonim.¹

SrS (aq.) . This value is obtained from those for the ions.

SrS (c.) . Sabatier¹ measured the heat of solution in aqueous HCl.

$\text{Sr(HS)}_2 \text{ (aq.)}$. Thomsen¹⁵ measured the heat of reaction of Sr(OH)_2 (aq.) with $2 \text{ H}_2\text{S (aq.)}$.

$\text{SrSO}_4 \text{ (aq.)}$. The value for $\text{SrSO}_4(\infty)$ is obtained from the ions. Thomsen¹⁵ measured the heat of reaction of Sr(OH)_2 (aq.) with H_2SO_4 (aq.). Chroustchhoff and Martinoff¹ and Berthelot⁹ measured the heats of reaction of SrCl_2 (aq.) with Na_2SO_4 (aq.) and of SrSO_4 (aq.) with 2 NaCl (aq.) . We have estimated the values for the heat of dilution.

$\text{SrSO}_4 \text{ (c.)}$. Barre¹ and Thomsen¹⁵ reported the heat of solution of strontium sulfate to be 0.0.

$\text{SrS}_2\text{O}_6 \text{ (aq.)}$. This value is obtained from those for the aqueous ions.

$\text{Sr(S}_2\text{O}_6)_2 \cdot 4 \text{ H}_2\text{O (c.)}$. Thomsen¹⁵ measured the heat of solution.

$\text{SrI}_2 \cdot n\text{SO}_2 \text{ (c.)}$. Ephraim and Kornblum¹ measured the dissociation pressures of $\text{SrI}_2 \cdot 2 \text{ SO}_2 \text{ (c.)}$ and $\text{SrI}_2 \cdot 4 \text{ SO}_2 \text{ (c.)}$.

SrSe (aq.) . Fabre¹ measured the heat of neutralization of Sr(OH)_2 (aq.) with $\text{H}_2\text{Se (aq.)}$.

SrSe (c.) . Fabre¹ measured the heat of solution.

$\text{SrN}_6 \text{ (c.)}$. Wohler and Martin¹ measured the heat of decomposition of strontium azide to be 49.0.

$\text{Sr}_3\text{N}_2 \text{ (c.)}$. Guntz and Benoit¹ measured the heat of solution of strontium nitride in aqueous HCl.

$\text{SrN}_2\text{O}_2 \text{ (aq.)}$. Berthelot¹⁰ reported a value for the heat of neutralization of Sr(OH)_2 (aq.) with $\text{H}_2\text{N}_2\text{O}_2 \text{ (aq.)}$.

$\text{SrN}_2\text{O}_2 \cdot 5 \text{ H}_2\text{O (c.)}$. Berthelot¹⁰ measured the heat of solution of the pentahydrate in bromine water.

$\text{Sr(NO}_3)_2 \text{ (aq.)}$. Thomsen¹⁵ and Berthelot⁹ reported values for the heat of neutralization of Sr(OH)_2 (aq.) with $2 \text{ HNO}_3 \text{ (aq.)}$. The value for $\text{Sr(NO}_3)_2(\infty)$ is obtained from those for the ions. Data on the heat of dilution of aqueous strontium nitrate were reported by Pratt,¹ Thomsen,¹⁵ Lange and Streeck,² and Hammerschmid and Lange.¹

$\text{Sr(NO}_3)_2 \text{ (c.)}$. The existing data yield the following values for S_{400} : Thomsen,¹⁵ -4.62 ; Pickering,⁷ -5.04 ; Berthelot,^{9, 131} -5.1 . See also Favre and Valson.²

$\text{Sr(NO}_3)_2 \cdot 4 \text{ H}_2\text{O (c.)}$. The existing data yield for S_{400} the following values: Thomsen,¹⁵ -12.30 ; Pickering,⁷ $-6.8 (?)$; Favre and Silbermann,³ -11.7 ; Berthelot,⁹ -12.1 .

$\text{Sr(NH}_4)_2 \text{ (c.)}$. Guntz and Benoit¹ measured the heat of solution in aqueous HCl.

$\text{Sr} \cdot 6 \text{ NH}_3 \text{ (c.)}$. Biltz and Hüttig³ measured the dissociation pressures.

$\text{SrX}_2 \cdot n\text{NH}_3 \text{ (c.)}$. Hüttig² reported dissociation pressure data on the mono-, di-, and octammines of SrCl_2 and SrBr_2 and on the mono-, di-, hexa-, and octammines of SrI_2 . Buffington¹ reported data on the di- and octammines of SrCl_2 .

$\text{SrSO}_4 \cdot (\text{NH}_4)_2\text{SO}_4 \text{ (c.)}$. Barre¹ measured the heat of solution.

$\text{Sr}_3(\text{PO}_4)_2$ (c, ppt.). Berthelot^{52, 101} measured the heat of reaction of H_3PO_4 (aq.) with $1\frac{1}{2}\text{Sr}(\text{OH})_2$ (aq.). See also Joly.⁴

SrHPO_4 (aq.). Berthelot^{52, 101} measured the heat of reaction of H_3PO_4 (aq.) with $\text{Sr}(\text{OH})_2$ (aq.). See also Joly.⁴

$\text{Sr}(\text{H}_2\text{PO}_4)_2$ (aq.). Berthelot^{52, 101} measured the heat of reaction of H_3PO_4 (aq.) with $\frac{1}{2}\text{Sr}(\text{OH})_2$ (aq.). See also Joly.⁴

$\text{Sr}_3(\text{AsO}_4)_2$ (c, ppt.). Blarez¹ measured the heat of reaction of H_3AsO_4 (aq.) with $1\frac{1}{2}\text{Sr}(\text{OH})_2$ (aq.).

SrHAsO_4 (aq.). Blarez¹ measured the heat of reaction of H_3AsO_4 (aq.) with $\text{Sr}(\text{OH})_2$ (aq.).

$\text{Sr}(\text{H}_2\text{AsO}_4)_2$ (aq.). Blarez¹ measured the heat of reaction of H_3AsO_4 (aq.) with $\frac{1}{2}\text{Sr}(\text{OH})_2$ (aq.).

SrCO_3 (c). Thomsen¹⁵ found $Q=0.23$ for the reaction of SrCl_2 (400) with Na_2CO_3 (400). Dissociation pressure data were reported by Johnston^{1, 4} and Dutoit.¹

$\text{Sr}(\text{HCO}_3)_2$ (aq.). Randall and White⁸ calculated, from the data of Haehnel,^{1, 2} $Q=6.74$ for the reaction, SrCO_3 (c) + CO_2 (g) + H_2O (liq.) = $\text{Sr}(\text{HCO}_3)_2$ (aq.), and from the data of McCoy and Smith,¹ $Q=1.94$ for the reaction, SrCO_3 (c) + H_2CO_3 (aq.) = $\text{Sr}(\text{HCO}_3)_2$ (aq.).

$\text{Sr}(\text{CHO}_2)_2$ (aq.). Thomsen¹⁵ measured the heat of neutralization of aqueous formic acid with aqueous strontium hydroxide.

$\text{Sr}(\text{CHO}_2)_2$ (c). Berthelot^{10, 131} measured the heat of solution of strontium formate.

$\text{Sr}(\text{CHO}_2)_2 \cdot 2\text{H}_2\text{O}$ (c). Berthelot^{10, 131} measured the heat of solution.

$\text{SrC}_2\text{O}_4 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ (c). Berthelot¹⁰ found $Q=35.2$ for the reaction, $\text{H}_2\text{C}_2\text{O}_4$ (aq.) + $\text{Sr}(\text{OH})_2$ (aq.) + $\frac{1}{2}\text{H}_2\text{O}$ (liq.) = $\text{SrC}_2\text{O}_4 \cdot 2\frac{1}{2}\text{H}_2\text{O}$ (c).

$\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2$ (aq.). Berthelot^{10, 131} measured the heat of neutralization of aqueous strontium hydroxide with aqueous acetic acid. The value for strontium acetate at infinite dilution is obtained from those for the aqueous ions.

$\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2$ (c). Berthelot^{10, 131} measured the heat of solution.

$\text{Sr}(\text{C}_2\text{H}_3\text{O}_2)_2 \cdot \frac{1}{2}\text{H}_2\text{O}$ (c). Berthelot^{10, 131} measured the heat of solution.

$\text{Sr}(\text{C}_2\text{H}_3\text{O}_3)_2$ (aq.). de Forcrand³ measured the heat of neutralization of aqueous glycollic acid with aqueous strontium hydroxide.

$\text{Sr}(\text{C}_2\text{H}_3\text{O}_3)_2$ (c). de Forcrand³ measured the heat of solution.

$\text{SrBr}_2 \cdot 1\frac{1}{2}\text{CH}_3\text{OH}$ (c). Lloyd, Brown, Bonnell, and Jones¹ measured the dissociation pressures of this alcoholate.

$\text{Sr}(\text{CN})_2$ (aq.). Joannis¹ measured the heat of neutralization of 2 HCN (aq.) with $\text{Sr}(\text{OH})_2$ (aq.).

$\text{Sr}(\text{CN})_2 \cdot 4\text{H}_2\text{O}$ (c). Joannis¹ measured the heat of solution.

SrSiO_3 (gls.). Tschernobaeff¹ reported $Q=-35.1$ for the reaction, SrCO_3 (c) + SiO_2 (c) = SrSiO_3 (gls.) + CO_2 (g).

$\text{SrI}_2 \cdot 2\text{PbI}_2 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous double salt and of the heptahydrate.

SrHg_∞ (liq.). The equilibrium data of Smith and Braley¹ yield 59.5 for the heat of solution of strontium in a very large amount of mercury.

SrBr₂ · nHgBr₂ (aq.). Varet⁶ measured the heats of mixing SrBr₂ (aq.) with $\frac{1}{2}$, 1, and 2 HgBr₂ (aq.), respectively.

Sr(CN)₂ · Hg(CN)₂ (aq.). Varet⁶ measured the heats of mixing Sr(CN)₂ (aq.) with 1 and 2 Hg(CN)₂ (aq.), respectively.

SrX₂ · 2Hg(CN)₂ (aq.). Varet⁶ measured the heats of mixing 2 Hg(CN)₂ (aq.) with SrCl₂ (aq.), SrBr₂ (aq.), and SrI₂ (aq.), respectively.

SrX₂ · 2Hg(CN)₂ · nH₂O (c). Varet⁶ measured the heats of solution of the chloride hexahydrate, the bromide hexahydrate, and the iodide heptahydrate.

Sr(CN)₂ · nAgCN (aq.). Varet⁵ measured the heat of reaction of Sr(CN)₂ (aq.) with 1 and 2 AgCN (c), respectively.

Sr(CN)₂ · Ni(CN)₂ (aq.). Varet⁴ measured the heat of mixing Sr(CN)₂ (aq.) with Ni(CN)₂ (aq.).

3 SrCl₂ · 4 AlCl₃ (c). Baud¹ measured the heat of solution.

SrWO₄ (c). For the reaction, SrO (c) + WO₃ (c) = SrWO₄ (c), Tamman and Westerholt¹ reported $Q = 56.4$ (?).

Sr₃(FeCO(CN)₅)₂ (aq.). Muller^{9, 10} measured the heat of neutralization of H₃FeCO(CN)₅ (aq.) with $1\frac{1}{2}$ Sr(OH)₂ (aq.).

Sr₃(FeCO(CN)₅)₂ · nH₂O (c). Muller^{9, 10} measured the heats of solution of the anhydrous salt and of the tetrahydrate.

BARIUM

Ba (c). Standard state.

Ba (liq.). We have estimated the heat of fusion.

Ba (g). We have estimated the heat of sublimation from the data of Ruff and Hartmann¹ and Hartmann and Schneider.¹ See also Sherman.¹ The energy states of gaseous monatomic barium are evaluated from the data of Hansen and Thorsen,¹ Russell and Saunders,¹ and Fowler.³

BaCl₂ (aq.). Guntz and Benoit^{1, 2} found $Q = 128.4$ for the reaction, Ba (c) + 2 HCl(140) = BaCl₂(280) + H₂ (g), at 7°; whence, for BaCl₂ (200), $Q_f = 207.3$. With less pure samples, Thomsen¹⁵ and Guntz³ measured the heat of solution of barium in aqueous HCl and Guntz³ that in water. Data on the heat of dilution of aqueous barium chloride were reported by Pratt,¹ Magie,¹ Richards and Dole,¹ Lehtonen,¹ Perreu,² Smith, Stearns, and Schneider,¹ and Lange and Streeck.¹

Ba⁺⁺(∞). This value is obtained from those for BaCl₂(∞) and Cl⁻(∞).

BaO (c). de Forcrand^{11, 48, 51} measured the heat of solution of barium oxide in 600 H₂O to be 35.64 at 15°. For the heat of solution of barium oxide in aqueous HCl, Berthelot²² found 55.58 in 2 HCl(300) at 11°, and Thomsen¹⁵ 62.30 in 2 HCl(200) at 18°.

BaO (g). Vapor pressure data were reported by Thompson and Armstrong¹ and Classen and Veeneman.¹

BaO₂ (c). Berthelot^{30, 61} measured the heat of solution of barium peroxide in aqueous HCl and in aqueous (SnCl₂ + 5 HCl). Dissociation pressure data on BaO₂ (c) were reported by LeChatelier⁶ and Hildebrand,¹ and reviewed by Biltz⁸ and Lewis and Randall.⁵

BaO₂ · nH₂O (c). Berthelot⁶¹ measured the heat of solution of the mono- and decahydrates in aqueous HCl, and de Forcrand^{26, 27} that of the decahydrate.

BaO₂ · H₂O₂ (c). Berthelot⁶¹ and de Forcrand^{26, 27} measured the heat of solution in aqueous HCl.

Ba(OH)₂ (aq.). Data on the heat of neutralization of Ba(OH)₂ (aq.) with 2 HCl (aq.) were reported by Anderson and Noyes,¹ von Steinwehr,¹ Berthelot,²² and Thomsen.¹⁵ The value for barium hydroxide at infinite dilution is obtained from those for aqueous barium and hydroxyl ions.

Ba(OH)₂ (c). The data on the heat of solution of barium hydroxide are: Thomsen,¹⁵ 12.26₈₀₀; Berthelot,²² 40.0 and 38.0 in aqueous HCl; de Forcrand,^{11, 48, 51} 11.60₆₆₀¹⁵. See also Johnston.⁵

Ba(OH)₂ · nH₂O (c). de Forcrand^{11, 48, 51} measured the heat of solution of the monohydrate. For the heat of solution of the octahydrate, the data are: Thomsen,¹⁵ -15.21₈₀₀; Berthelot,²² -13.0; de Forcrand,⁵¹ -14.50₆₆₀¹⁵; Sill,¹ -15.8.

BaH₂ (c). For the heat of solution of barium hydride in aqueous HCl at 7°, Guntz and Benoit¹ found 87.6. See also Guntz¹⁶ and Kassarnowsky.^{1, 2}

Ba₂O (c). Benoit² measured the heat of solution in aqueous HCl.

BaF₂ (aq.). The value for infinite dilution is obtained from those for the aqueous ions.

BaF₂ (c). Petersen³ measured the heat of reaction of BaCl₂ (aq.) with 2 AgF (aq.). Guntz¹ and Petersen³ measured the heat of reaction of Ba(OH)₂ (aq.) with 2 HF (aq.). Petersen³ reported the heat of solution of BaF₂ (c) to be -2.0.

BaCl₂ (c). Data on the heat of solution of barium chloride were reported by Thomsen,¹⁵ Berthelot,^{7, 22} Berthelot and Ilosvay,¹ Benoit,² Baud,¹ Schottky,¹ Kolosovskii,⁵ and Lehtonen.¹ See also Cambi and Devoto.¹

BaCl₂ · H₂O (c). Schottky¹ measured the heat of solution. Dissociation pressure data were reported by Foote and Scholes,¹ Lescœur,² Muller-Erbach,¹ and Trip¹ (see Hüttig and Slonim¹).

BaCl₂ · 2 H₂O (c). Data on the heat of solution of the dihydrate were reported by Thomsen,¹⁵ Berthelot,⁷ Favre and Silbermann,³ Kolosovskii,⁵ Perreu,¹ and Favre and Valson.² Dissociation pressure data were reported by Trip¹ (see Hüttig and Slonim¹), Baxter and Cooper,¹ Menzies,¹ Foote and Scholes,¹ Schumb,¹ Frowein,¹ Schottky,¹ Cohen,⁴ Muller-Erbach,^{3, 4} Partington,¹ and Lescœur.²

Ba(ClO)₂ (aq.). Berthelot²⁶ and Neumann and Muller² measured the heat of reaction of Ba(OH)₂ (aq.) with Cl₂ (g), and Neumann and Muller² that of Ba(OH)₂ (aq.) with 2 HClO (aq.).

$\text{Ba}(\text{ClO}_2)_2$ (c). Bruni and Levi¹ reported the heat of dissociation of barium chlorite into barium chloride and oxygen.

$\text{Ba}(\text{ClO}_3)_2$ (aq.). Berthelot²⁹ and Thomsen¹⁵ measured the heat of reduction of aqueous barium chlorate with aqueous sulfur dioxide. The value for $\text{Ba}(\text{ClO}_3)_2$ (∞) is obtained from those for the aqueous ions at infinite dilution.

$\text{Ba}(\text{ClO}_3)_2$ (c). Berthelot⁹ measured the heat of solution.

$\text{Ba}(\text{ClO}_3)_2 \cdot \text{H}_2\text{O}$ (c). For the heat of solution, Thomsen¹⁵ found -11.24_{600} and Berthelot⁹ -11.48_{500} ¹⁰.

$\text{Ba}(\text{ClO}_4)_2$ (aq.). Thomsen¹⁵ and Berthelot⁷⁹ measured the heat of neutralization of aqueous perchloric acid with aqueous barium hydroxide. The value for $\text{Ba}(\text{ClO}_4)_2$ (∞) is obtained from those for Ba^{++} (∞) and ClO_4^- (∞).

$\text{Ba}(\text{ClO}_4)_2 \cdot n\text{H}_2\text{O}$ (c). Berthelot⁹ measured the heats of solution of the anhydrous salt and the trihydrate.

$\text{BaCl}_2 \cdot \text{BaO} \cdot n\text{H}_2\text{O}$ (c). Andre^{1, 3} measured the heats of solution of the tri-, penta-, and octahydrates, but reported his results in terms of the heat of the reaction, BaCl_2 (c) + BaO (c) + $n\text{H}_2\text{O}$ (liq.) = $\text{BaCl}_2 \cdot \text{BaO} \cdot n\text{H}_2\text{O}$ (c), without stating the values used for the heat of formation of BaO (c). However, the value of Q_f for the pentahydrate can be computed from the data of Tassilly⁴ who measured its heat of solution in aqueous HCl to be 18.5, and the differences between the various hydrates can then be obtained from the data of Andre.^{1, 3}

BaBr_2 (aq.). The value for barium bromide at infinite dilution is obtained from those for the aqueous ions. Data on the heat of dilution of aqueous barium bromide were reported by Lange and Streeck.¹

BaBr_2 (c). The data on the heat of solution are: Thomsen,¹⁵ 4.98₄₀₀; Varet,² 4.0. See also Cambi and Devoto.¹

$\text{BaBr}_2 \cdot \text{H}_2\text{O}$ (c). Dissociation pressure data were reported by Lescoeur⁷ and Trip¹ (see Hüttig and Slonim¹).

$\text{Ba}(\text{BrO})_2$ (aq.). Berthelot⁴⁵ measured the heat of reaction of aqueous barium hydroxide with bromine.

$\text{Ba}(\text{BrO}_3)_2$ (aq.). These values are obtained from those for the ions.

$\text{Ba}(\text{BrO}_3)_2 \cdot \text{H}_2\text{O}$ (c). Greensfelder and Latimer¹ measured the heat of solution.

$\text{BaBr}_2 \cdot \text{BaO} \cdot n\text{H}_2\text{O}$ (c). Tassilly⁵ measured the heats of solution of the di- and pentahydrates in aqueous HBr.

BaI_2 (aq.). The value for infinite dilution is obtained from those for the aqueous ions. We have estimated the heat of dilution.

BaI_2 (c). Tassilly^{1, 3} measured the heat of solution. See also Cambi and Devoto.¹

$\text{BaI}_2 \cdot n\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution of the heptahydrate. Dissociation pressure data on the hydrates with 1, 2, 2½, and 7 H₂O were reported by Trip¹ (see Hüttig and Slonim¹).

$\text{Ba}(\text{IO}_3)_2$ (aq.). This value is obtained from those for the aqueous ions.

Ba(IO₃)₂ (c). Chroustchoff¹ measured the heat of reaction of this salt with K₂SO₄ (aq.) to be -4.6.

Ba(IO₃)₂ · H₂O (c). Chroustchoff¹ measured the heats of reaction of BaCl₂ (aq.) with 2 KIO₃ (aq.), of Ba(NO₃)₂ (aq.) with 2 KIO₃ (aq.), and of Ba(NO₃)₂ (aq.) with 2 HIO₃ (aq.) to be 11.0, 10.6, and 13.5, respectively, at 13°. The iodate formed in these reactions is barium iodate monohydrate.

BaI₂ · BaO · nH₂O (c). Tassilly¹ measured the heats of solution of the di- and nonhydrates in aqueous HI.

BaS (aq.). Thomsen¹⁵ and Sabatier¹ measured the heat of neutralization of H₂S (aq.) with Ba(OH)₂ (aq.). The value for infinite dilution is obtained from those for the aqueous ions.

BaS (c). Sabatier¹ measured the heat of solution in aqueous HCl.

BaSO₃ (c). de Forcrand³ measured the heat of reaction of H₂SO₃ (aq.) with Ba(OH)₂ (aq.).

Ba(HSO₃)₂ (aq.). de Forcrand³ measured the heat of reaction of Ba(OH)₂ (aq.) with 2 H₂SO₃ (aq.).

BaSO₄ (c). Thomsen¹⁵ measured the heats of the reactions of Ba(OH)₂(400) with H₂SO₄(400) and of BaCl₂(400) with H₂SO₄(400) to be 36.90 and 4.15, respectively; whence, for BaSO₄ (c), $Q_f = 349.49$ and 349.20. See also Berthelot⁹ and Muller.¹⁰ Melcher¹ calculated the heat of solution of barium sulfate to be -6.0, from conductivity measurements at various temperatures.

BaS₂O₆ (aq.). Thomsen¹⁵ measured the heat of reaction of BaS₂O₆ (aq.) with H₂SO₄(400).

BaS₂O₆ · 2 H₂O (c). Thomsen¹⁵ measured the heat of solution.

BaS₂O₈ (aq.). Berthelot¹⁰⁷ measured the heat of reaction of BaS₂O₈ (aq.) with H₂SO₄ (aq.).

BaS₂O₈ · 4 H₂O (c). Berthelot¹⁰⁷ measured the heat of solution.

BaS₄O₆ (aq.). This value is obtained from the ions.

BaS₄O₆ · 2 H₂O (c). Portillo¹ measured the heat of solution.

Ba(HS)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of Ba(OH)₂ (aq.) with 2 H₂S (aq.).

BaSO₄ · H₂SO₄ (c). Volchowsky¹ measured the heat of solution.

BaSO₄ · 2 H₂SO₄ · H₂O (c). Volchowsky¹ measured the heat of solution.

BaI₂ · nSO₂ (c). Ephraim and Kornblum¹ reported dissociation pressure data on BaI₂ · 2 SO₂ (c) and BaI₂ · 4 SO₂ (c).

BaSe (c). Fabre¹ measured the heat of solution in aqueous HCl.

BaSeO₄ (c). Metzner¹ measured the heat of reaction of BaCl₂ (aq.) with H₂SeO₄ (aq.).

Ba(N₃)₂ (aq.). Berthelot and Matignon measured the heat of neutralization of 2 HN₃ (aq.) with Ba(OH)₂ (aq.).

Ba(N₃)₂ (c). Berthelot and Matignon measured the heat of solution.

Ba₃N₂ (c). Guntz and Benoit¹ measured the heat of solution in aqueous HCl. See also Guntz.¹⁶

Ba(NO₂)₂ (aq.). Berthelot²⁸ measured the heat of reaction of Ba(NO₂)₂ (aq.) with H₂SO₄ (aq.).

Ba(NO₂)₂ (c). Berthelot²⁸ measured the heat of solution

Ba(NO₂)₂ · 2 H₂O (c). Berthelot²⁸ measured the heat of solution.

Ba(NO₃)₂ (aq.). Thomsen¹⁵ measured the heats of reaction of H₂SO₄(400) with Ba(OH)₂(400) and Ba(NO₃)₂(400) to be 28.28 and 8.56, respectively; whence, for Ba(NO₃)₂(800), $Q_f = 227.19$ and 227.92 . Berthelot^{9, 12} reported $Q = 28.0$ and 5.2 for the reactions of H₂SO₄(400) with Ba(OH)₂(400) and of Ba(NO₃)₂(400) with K₂SO₄(400). Data on the heat of dilution of aqueous barium nitrate were reported by Pratt,¹ Bishop,¹ Stackelberg,¹ Lange and Streeck,² and Hammerschmid and Lange.¹

Ba(NO₃)₂ (c). The data on the heat of solution are: Thomsen,¹⁵ -9.47_{400} ; Stackelberg,¹ -10.03_{1000} ¹⁶; Berthelot,^{9, 131} -9.28_{1000} ¹².

BaNH (c). Guntz and Benoit¹ measured the heat of solution in aqueous HCl.

Ba(NH₂)₂ (c). Guntz and Benoit¹ measured the heat of solution in aqueous HCl.

Ba · 6 NH₃ (c). Biltz and Hüttig² measured the dissociation pressure.

BaX₂ · nNH₃ (c). Dissociation pressure data on the octammine of barium chloride were reported by Hüttig and Martin¹ and Gillespie and Lurie.¹ Hüttig and Martin¹ reported dissociation pressure data on the amines of BaBr₂ with 1, 2, 4, and 8 NH₃, and those of BaI₂ with 2, 4, 6, 8, 9, and 10 NH₃.

Ba₃(PO₄)₂ (c, ppt.). Berthelot and Louguinine³ recomputed the data of Berthelot,⁵² who measured the heat of reaction of H₃PO₄ (aq.) with $1\frac{1}{2}$ Ba(OH)₂ (aq.) to form the crystalline precipitate and also to form the colloid, to be 60.8 and 78.2, respectively. See also Joly.^{3, 4}

BaHPO₄ (aq.). Berthelot and Louguinine³ recomputed Berthelot's⁵² data on the heat of reaction of H₃PO₄ (aq.) with Ba(OH)₂ (aq.). See also Berthelot¹⁰¹ and Joly.^{3, 4}

Ba(H₂PO₄)₂ (aq.). Berthelot and Louguinine³ recalculated the data of Berthelot⁵² on the heat of reaction of H₃PO₄ (aq.) with $\frac{1}{2}$ Ba(OH)₂ (aq.). See also Joly.^{3, 4}

BaH₂P₂O₆ (aq.). Joly³ measured the heat of reaction of H₄P₂O₆ (aq.) with Ba(OH)₂ (aq.) to be 35.4.

Ba(H₂PO₂)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of this substance with H₂SO₄ (aq.).

Ba(H₂PO₂)₂ · H₂O (c). Thomsen¹⁵ measured the heat of solution.

Ba₃(AsO₄)₂ (c, ppt.). Blarez² measured the heat of reaction of H₃AsO₄ (aq.) with $1\frac{1}{2}$ Ba(OH)₂ (aq.).

BaHAsO₄ (aq.). Blarez² measured the heat of reaction of H₃AsO₄ (aq.) with Ba(OH)₂ (aq.). See also Joly.³

Ba(H₂AsO₄)₂ (aq.). Blarez² measured the heat of reaction of H₃AsO₄ (aq.) with $\frac{1}{2}$ Ba(OH)₂ (aq.).

BaHAsO₃ (aq.). Thomsen¹⁵ measured the heat of reaction of H₃AsO₃ (aq.) with Ba(OH)₂ (aq.).

Ba(H₂AsO₃)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of H₃AsO₃ (aq.) with $\frac{1}{2}$ Ba(OH)₂ (aq.).

BaCO₃ (c). Thomsen¹⁵ measured the heats of reaction of BaCl₂ (aq.) with Na₂CO₃ (aq.) and with K₂CO₃ (aq.), and the heat of neutralization of H₂CO₃ (aq.) with Ba(OH)₂ (aq.). See also Berthelot.^{9, 12} Dissociation pressure data were reported by Johnston,⁵ Dutoit,¹ Abich,¹ Isambert,⁴ Brill,² and Finkelstein.¹

BaO · BaCO₃ (c). Finkelstein¹ reported dissociation pressure data for the reaction, 2 BaCO₃ (c) = BaO · BaCO₃ (c) + CO₂ (g).

BaC₂O₄ · H₂O (c). Berthelot¹⁰ measured the heat of reaction of aqueous oxalic acid with aqueous barium hydroxide to form the monohydrate.

Ba(HCO₃)₂ (aq.). Randall and Tamale² reviewed the data of Schloesing,^{1, 2} Haehnlel,^{1, 2} and McCoy and Smith¹ on the solubility of barium carbonate in aqueous carbonic acid, and calculated $Q = 7.86$ for the reaction, BaCO₃ (c) + CO₂ (g) + H₂O (liq.) = Ba(HCO₃)₂ (aq.).

Ba(CHO₂)₂ (aq.). Berthelot³¹ measured the heats of reaction of Ba(CHO₂)₂ (aq.) with 2 HCl (aq.), of BaCl₂ (aq.) with 2 HCHO₂ (aq.), and of H₂SO₄ (aq.) with Ba(CHO₂)₂ (aq.).

Ba(CHO₂)₂ (c). Berthelot⁷ measured the heat of solution of barium formate.

Ba(C₂H₃O₂)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of aqueous barium acetate with aqueous sulfuric acid. Berthelot^{7, 9} and Thomsen¹⁵ measured the heat of neutralization of aqueous barium hydroxide with aqueous acetic acid. The value for barium acetate at infinite dilution is obtained from those for the aqueous ions.

Ba(C₂H₃O₂)₂ (c). Berthelot^{7, 9} measured the heat of solution.

Ba(C₂H₃O₂)₂ · 3 H₂O (c). Berthelot^{7, 9} measured the heat of solution.

Ba(C₂H₃O₃)₂ (aq.). The value for aqueous barium glycollate is obtained from those for the ions.

Ba(C₂H₃O₃)₂ (c). de Forcrand³ measured the heat of solution of barium glycollate.

3 BaO · 4 CH₃OH (c). de Forcrand^{2, 16, 18} measured the heat of solution in aqueous HCl.

3 BaO · 4 C₂H₅OH (c). de Forcrand^{2, 16, 18} measured the heat of solution.

Ba(C₂H₅O)₂ (c). de Forcrand^{2, 16, 18} measured the heat of solution.

Ba(C₂H₅SO₄)₂ (aq.). Thomsen¹⁵ measured the heat of reaction of Ba(C₂H₅SO₄)₂(400) with H₂SO₄(400) to be 9.34.

Ba(C₂H₅SO₄)₂ · 2 H₂O (c). Thomsen¹⁵ measured the heat of solution.

Ba(CN)₂ (aq.). Joannis¹ measured the heat of neutralization of 2 HCN (aq.) with Ba(OH)₂ (aq.).

Ba(CN)₂ · nH₂O (c). Joannis¹ measured the heats of solution of the anhydrous salt and the mono- and dihydrates.

BaSiO₃ (gls.). Tschernobaeff¹ reported $Q = -41.0$ for the reaction, $\text{SiO}_2 (\text{c}) + \text{BaCO}_3 (\text{c}) = \text{BaSiO}_3 (\text{gls.}) + \text{CO}_2 (\text{g})$, from calorimetric experiments, and Jander¹ calculated $Q = -34.0$ for the same reaction from equilibrium data. These data yield, for BaSiO₃ (gls.), $Q_f = 359$ and 366. See also Marchal.¹

Ba(CNO)₂ (aq.). Lemoult¹ measured the heats of decomposition of aqueous barium cyanate with aqueous sulfuric acid and with aqueous nitric acid.

Ba(CNO)₂ (c). Lemoult¹ measured the heat of solution.

BaSiF₆ (c). Hantke¹ measured the heat of reaction of H₂SiF₆ (aq.) with Ba(OH)₂ (aq.), and also the dissociation pressures of BaSiF₆ (c).

BaI₂ · 2 PbI₂ · nH₂O (c). Mosnier¹ measured the heats of solution of the anhydrous double salt and the heptahydrate.

BaBr₂ · nHgBr₂ (aq.). Varet⁶ measured the heats of mixing BaBr₂ (aq.) with $\frac{1}{2}$, 1, and 2 HgBr₂ (aq.), respectively.

Ba(CN)₂ · nHg(CN)₂ (aq.). Varet² measured the heats of mixing Ba(CN)₂ (aq.) with $\frac{1}{2}$, 1, and 2 Hg(CN)₂ (aq.), respectively.

BaX₂ · 2 Hg(CN)₂ (aq.). Varet^{2, 6} measured the heats of mixing 2 Hg(CN)₂ (aq.) with BaCl₂ (aq.), BaBr₂ (aq.), and BaI₂ (aq.), respectively.

BaX₂ · 2 Hg(CN)₂ · nH₂O (c). Varet^{2, 6} measured the heats of solution of the chloride pentahydrate, the bromide hexahydrate, and the iodide tetrahydrate.

Ba(CN)₂ · nAgCN (aq.). Varet¹ measured the heats of reaction of Ba(CN)₂ (aq.) with 1 and 2 AgCN (c), respectively.

BaPtCl₆ (aq.). This value is obtained from the ions. Gire^{1, 3} measured the heat of reaction of aqueous barium chloroplatinate with cobalt.

BaPtCl₆ · nH₂O (c). Gire^{1, 3} measured the heats of solution of the anhydrous salt and the hexahydrate, and the dissociation pressures of BaPtCl₆ (c).

Ba₂Fe(CN)₆ (aq.). Joannis¹ measured the heat of reaction of H₄Fe(CN)₆ (aq.) with 2 Ba(OH)₂ (aq.).

BaH₂Fe(CN)₆ (aq.). Joannis¹ measured the heat of reaction of H₄Fe(CN)₆ (aq.) with Ba(OH)₂ (aq.).

Ba₂Fe(CN)₆ · 6 H₂O (c). Joannis¹ measured the heat of solution.

Ba₃(FeCO(CN)₅)₂ (aq.). Muller^{9, 10} measured the heat of reaction of H₃FeCO(CN)₅ (aq.) with $1\frac{1}{2}$ Ba(OH)₂ (aq.).

Ba₃(FeCO(CN)₅)₂ · nH₂O (c). Muller^{9, 10} measured the heats of solution of the anhydrous salt and of the undecahydrate.

BaHFeCO(CN)₅ (aq.). Muller^{9, 10} measured the heat of reaction of H₃FeCO(CN)₅ (aq.) with Ba(OH)₂ (aq.).

Ba(H₂FeCO(CN)₅)₂ (aq.). Muller^{9, 10} measured the heat of reaction of H₃FeCO(CN)₅ (aq.) with $\frac{1}{2}$ Ba(OH)₂ (aq.).

$\text{Ba}(\text{CN})_2 \cdot \text{Ni}(\text{CN})_2$ (aq.). Varet⁴ measured the heats of mixing $\text{Ba}(\text{CN})_2$ (aq.) with $\text{Ni}(\text{CN})_2$ (aq.).

BaCrO_4 (c). Chroustschoff and Martinoff¹ found $Q=6.8$ for the reaction of BaCl_2 (aq.) with K_2CrO_4 (aq.).

$\text{BaCl}_2 \cdot 2 \text{AlCl}_3$ (c). Baud¹ measured the heat of solution.

$3 \text{BaCl}_2 \cdot \text{AlCl}_3$ (c). Baud¹ measured the heat of solution.

BaMoO_4 (c). Tammann and Westerholt¹ reported $Q=60.1$ for the reaction of BaO (c) with MoO_3 (c).

BaWO_4 (c). Tammann and Westerholt¹ reported $Q=73.5$ for the reaction of BaO (c) with WO_3 (c).

RADIUM

Ra (c). Standard state.

LITHIUM

Li (c). Standard state.

Li (liq.). Thum¹ reported for the heat of fusion the value -0.23 ; Sherman¹ calculated -0.115 . Both of these values seem too low, because the entropy of fusion of the other alkali metals has the nearly constant value of 1.68 calories per degree per mole, and yields, for the heat of fusion, -0.77 .

Li (g). Vapor pressure data were reported by Bogros¹ and Hartmann and Schneider.¹ Utilizing the data of the latter investigation, and neglecting the small effect due to the probable existence of some diatomic molecules in the vapor, we have calculated, for Li (g), $Q_f = -39.0$. See also Sherman,¹ Joos and Hüttig,¹ and van Laar.⁹

The values for the energy states of the gaseous lithium atom are from the data of Ericson and Edlen¹ and Edlen and Ericson.³ See also Bacher and Goudsmit.¹

Li_2 (g). Loomis and Nusbaum¹ reported the energy of dissociation, Li_2 (g) $= 2 \text{Li}$ (g), with each substance in its normal state, to be 1.14 ± 0.03 volt-electrons.

LiOH (aq.). The heat of solution of Li (c) in water was measured by Thomsen,¹⁵ Guntz,³ Zukowsky,¹ and Moers.¹ These data have been recomputed, and give, respectively, for Li (c) + H_2O (liq.) $= \text{LiOH}$ (200) + $\frac{1}{2} \text{H}_2$ (g), the following values for Q : 49.11, 53.09, 52.6, and 52.73. The value of Moers is taken as the best one, whence for LiOH (200), $Q_f = 121.10$. The existing data on the heat of dilution of aqueous LiOH (de Forcrand,^{10, 48} Richards and Rowe²) were reviewed by Rossini,³ who gave values from ∞ to 25 H_2O .

Li^+ (∞). The foregoing data give, for Li^+ (∞) + OH^- (∞), $Q_f = 121.288$, whence, for Li^+ (∞), $Q_f = 66.628$.

LiOH (c). de Forcrand⁴⁴ measured the heat of solution of LiOH (c) in HCl (220), and later (de Forcrand⁴⁷) its heat of solution in H_2O . His data yield, respectively, for Q_f , 116.58 and 116.52. The average value, 116.55, gives $S = 4.55_{200}$. Truchot² found $S = 5.82_{400}$. See also Johnston.⁴

$\text{LiOH} \cdot n\text{H}_2\text{O}$ (c). de Forcrand⁵⁰ measured the heat of solution of $\text{LiOH} \cdot \frac{1}{3}\text{H}_2\text{O}$ (c) and also (de Forcrand⁴⁴) that of $\text{LiOH} \cdot \text{H}_2\text{O}$ (c).

Li_2O (c). de Forcrand⁴⁵ measured the heat of solution in water. See also Beketoff.²

$\text{Li}_2\text{O} \cdot \frac{3}{4}\text{H}_2\text{O}$ (c). de Forcrand⁵⁰ measured the heat of solution in water.

Li_2O_2 (aq.). de Forcrand³¹ measured the heat of reaction of HCl (aq.) with Li_2O_2 (aq.), and of LiOH (aq.) with H_2O_2 (aq.). His data yield, respectively, $Q_f = 159.5$ and 157.7 .

Li_2O_2 (c). de Forcrand³¹ measured the heat of solution in water.

LiH (c). The heat of formation of LiH can be computed from the difference in the heats of solution of Li (c) and LiH (c). The recalculated data of Guntz¹³ and Moers¹ yield almost identical values: $Q_f = 21.60$ and 21.59 , respectively.

LiH (g). The dissociation pressure data of Hüttig and Krajewski,¹ Guntz,¹³ and Ephraim and Michel¹ yield no reliable thermal values. Mulliken⁶ reported 2.47 volt-electrons for the energy of dissociation of gaseous normal LiH into gaseous normal Li and H atoms.

The values for the energy states of gaseous LiH are from Mulliken.⁶ See also Watson,² Nakamura,¹ and Jevons.¹

$\text{Li}_2\text{O}_2 \cdot \text{H}_2\text{O}_2 \cdot 3\text{H}_2\text{O}$ (c). de Forcrand³¹ measured the heat of solution of this compound in water to be -4.5 .

LiF (aq.). Petersen³ measured the heat of neutralization of HF (200) and LiOH (200). His data yield, for LiF (400), $Q_f = 144.69$.

Lange and Leighton² (see Robinson¹) gave values for the heat of dilution of LiF (aq.) at 25° , and their data have been used to obtain values at 18° from ∞ to $100\text{H}_2\text{O}$.

LiHF_2 (aq.). Petersen³ found, for 2HF (100) + LiOH (200) = LiHF_2 (401) + H_2O (liq.), $Q = 16.35$; whence, for LiHF_2 (400), $Q_f = 220.20$.

LiF (c). de Forcrand¹² measured the heat of solution.

LiF (liq.), LiF (g). Vapor pressure data were given by Ruff, Schmidt, and Mugdan,¹ and von Wartenberg and Schulz.¹ The latter investigators estimated $F = -6.0$. Taking $V = -52^{1600}$, we have computed, for LiF (c) = LiF (g), $Q = -63$.

LiCl (aq.). The heat of neutralization of HCl (aq.) with LiOH (aq.) was measured by Thomsen,¹⁵ Muller,¹ and Richards and Rowe.³ The most accurate data are those of Richards and Rowe, and these have been recomputed by Rossini,⁶ who gave $N = 14.077_{201}$. The data on the heat of dilution of LiCl (aq.) (Dunnington and Hoggard,¹ Lemoine,² Tucker,¹ Richards and Rowe²) were reviewed by Rossini,⁵ who gave values from ∞ to $25\text{H}_2\text{O}$. Lange and Dürr² gave values at 25° for the heat of dilution to $3\text{H}_2\text{O}$, and Lemoine,² at 10° , to $4.63\text{H}_2\text{O}$. These data have been converted to 18° and used to obtain values from 25 to $3\text{H}_2\text{O}$.

LiCl (c). The existing data on the heat of solution of LiCl have been recomputed to give the following values for S_{200} : Thomsen,¹⁵ 8.432 ;

Pickering,⁸ 8.100; Bonnefoi,¹ 8.50; Haigh,¹ 8.349; Lange and Dürr,² 8.480; Maier² (see Slonim and Hüttig¹), 8.33; Wasserman,¹ 8.544. The average of the values of Thomsen, Bonnefoi, Lange and Dürr, and Wasserman give 8.49 ± 0.03 .

LiCl (liq.). Zemczuzny¹ calculated $F = -3.7613$ from the freezing point depression. von Wartenberg and Schulz¹ estimated $F = -5.0$.

LiCl (g). The vapor pressure data of Ruff and Mugdan¹ and von Wartenberg and Schulz¹ yield $V = -37.3^{1200}$. Visser¹ interpreted the spectral fluorescent limit as dissociation, obtaining $D^z = -97$.

LiCl(CH₃OH), LiCl(C₂H₅OH). Lemoine² measured the heat of solution of LiCl (c) in various amounts of methyl alcohol at 18°, and of ethyl alcohol at 12°.

LiClO (aq.). Neumann and Müller² measured the heat of reaction of Cl₂ (g) with LiOH (aq.), and of LiOH (aq.) with HClO (aq.). Their data yield, respectively, $Q_f = 91.98$ and 92.63 , for LiClO (aq.).

LiCl · nH₂O (c). Bogorodskii¹ measured the heats of solution of the mono- and dihydrates. Maier² (see Slonim and Hüttig¹) measured the heat of solution of the monohydrate. Hüttig and Reuscher¹ measured the temperature coefficient of the dissociation pressures of the mono-, di-, and trihydrates.

LiBr (aq.). The heat of neutralization of HBr (aq.) with LiOH (aq.) was measured by Richards and Rowe.³ Their data have been recomputed, giving $N = 14.040_{201}$. The heat of dilution of LiBr (aq.) at 25° was measured by Lange and Messner² in the very dilute region, and by Lange and Schwartz¹ in the concentrated range. Their data have been converted to 18° to give values from ∞ to 3 H₂O.

LiBr (c). The data on the heat of solution of LiBr (c) have been recomputed to give the following values for S_{200} : Bodisko,² 11.39; Lange and Schwartz,¹ 11.37; Maier² (see Slonim and Hüttig¹), 11.51.

LiBr (liq.). We have estimated the heat of fusion.

LiBr (g). The vapor pressure data of Ruff and Mugdan¹ and von Wartenberg¹ yield $V = -36.5^{1200}$. Visser,¹ from the spectral fluorescent limit, computed $D^z = -78.4$.

LiBr · nH₂O (c). Maier² (see Slonim and Hüttig¹) measured the heats of solution of the mono- and dihydrates. Hüttig and Reuscher¹ measured the temperature coefficient of the dissociation pressures of the mono-, di-, and trihydrates.

LiI (aq.). The accurate data of Richards and Rowe³ have been recomputed, giving $N = 13.972_{201}$, whence, for LiI (200), $Q_f = 79.907$. From $\text{Li}^+(\infty) + \text{I}^-(\infty)$, one obtains, for LiI (∞), $Q_f = 79.998$. Using these two values, and extrapolating the series of curves representing the heats of dilution of LiF, LiCl, and LiBr, we have computed values of the heat of dilution of LiI (aq.) from ∞ to 100 H₂O.

LiI (c). The data on the heat of solution of the LiI (c) have been recomputed to give the following values for S_{200} : Bodisko,¹ 14.83; Maier² (see Slonim and Hüttig¹), 14.80; Mosnier,¹ 14.93. We have selected

14.83 as the best value, whence, for LiI (c), $Q_f = 65.08$. Beketoff⁸ measured the heats of solution of LiCl (c) + NaI (c), LiI (c) + NaCl (c), LiCl (c) + KI (c), and LiI (c) + KCl (c). From his data one finds, for LiI (c), $Q_f = 65.15$ and 65.10 , respectively.

LiI (liq.). We have estimated the heat of fusion.

LiI (g). The vapor pressure data of Ruff and Mugdan¹⁷ yield $V = -34.3^{1000}$.

$\text{LiI} \cdot n\text{H}_2\text{O}$ (c). Maier² (see Slonim and Hüttig¹) measured the heats of solution of the mono-, di-, and trihydrates. Hüttig and Pohle¹ measured the temperature coefficient of the dissociation pressures of the hemi-, mono-, di-, and trihydrates.

Li_2SO_4 (aq.). Thomsen¹⁵ measured the heat of neutralization of LiOH (200) with H_2SO_4 (400). Zukowsky¹ measured the heat of solution of Li (c) in H_2SO_4 (626). Thomsen's¹⁵ data yield $N = 31.27_{802}$, whence, for Li_2SO_4 (800), $Q_f = 348.57$ and for Li_2SO_4 (∞), $Q_f = 348.97$; whereas, from $2\text{Li}^+(\infty) + \text{SO}_4^{--}(\infty)$, one finds 349.056. The heat of dilution of Li_2SO_4 (aq.) was measured in the very dilute range by Lange and Streeck,¹ whose data have been used to obtain values at 18° from ∞ to 200 H_2O .

Li_2SO_4 (c, II). The existing data yield the following values for S_{200} : Thomsen,¹⁵ 5.96; Pickering^{2, 3} 6.18.

Li_2SO_4 (c, I). Hare¹ measured the heat of transition.

$\text{Li}_2\text{SO}_4 \cdot \text{H}_2\text{O}$ (c). The existing data have been recomputed to give the following for S_{400} : Thomsen,¹⁵ 3.41; Pickering,³ 3.26.

$\text{LiI} \cdot n\text{SO}_2$ (c). Ephraim and Kornblum¹ measured the temperature coefficient of the dissociation pressures of $\text{LiI} \cdot \text{SO}_2$ (c) and $\text{LiI} \cdot 2\text{SO}_2$ (c).

Li_2Se (aq.). Fabre¹ measured the heat of neutralization of LiOH (220) with H_2Se (g). His data yield, for Li_2Se (440), $Q_f = 95.3$.

$\text{Li}_2\text{Se} \cdot n\text{H}_2\text{O}$ (c). Fabre¹ measured the heats of solution of Li_2Se (c) and $\text{Li}_2\text{Se} \cdot 9\text{H}_2\text{O}$ (c).

Li_3N (c). Guntz¹⁴ measured the heat of solution.

LiNO_3 (aq.). The recomputed (see Rossini⁶) data of Richards and Rowe³ give $N = 13.931_{201}$. The heat of dilution data of Richards and Rowe,² 25 to 400 H_2O , were extrapolated to ∞ H_2O by Rossini,⁵ and we have extrapolated in the concentrated region to 3 H_2O .

LiNO_3 (c). The data on the heat of solution of LiNO_3 (c) have been recomputed to give the following values for S_{200} : Thomsen,¹⁵ 0.273; Berthelot, 0.331; Pickering,⁸ 0.329; Haigh,¹ 0.340.

LiNO_3 (liq.). Goodwin and Kalmus¹ measured the heat of fusion.

$\text{LiNO}_3 \cdot 3\text{H}_2\text{O}$ (c). Morgan and Benson¹ found, from measurement of the constant of the freezing point lowering, $F^{29.9} = -8.7$. This gives, at 18° , $F = -8.4$, which is equivalent to S_3 .

$\text{LiNO}_3(\text{C}_2\text{H}_5\text{OH})$. Pickering⁸ measured the heat of solution of LiNO_3 (c) in ethyl alcohol.

LiNH_2 (c). Guntz and Benoit¹ measured the heat of solution in HCl (aq.).

$\text{Li}(\text{NH}_3)_4$ (liq.). Kraus¹ and Benoit¹ measured the temperature coefficient of the dissociation pressure.

Li_2NH (c). Guntz and Benoit¹ measured the heat of solution in HCl (aq.).

Li_2C_2 (c). The heat of solution in water was measured by Guntz.¹⁵

Li_2CO_3 (aq.). Muller¹ measured the heat of reaction between 2HCl (90) and Li_2CO_3 (1800); de Forcrand⁴⁹ that between 2LiOH (100) and CO_2 (1800). Their data yield, respectively, for Li_2CO_3 (2000), $Q_f = 293.31$ and 293.27 .

LiHCO_3 (aq.). Muller¹ measured the heat of reaction between 2HCl (90) and 2LiHCO_3 (980). Combination of these data with his values for the reaction between 2HCl (90) and Li_2CO_3 (1800), gives, for the heat of reaction between Li_2CO_3 (1800) and H_2CO_3 (2000) to form 2LiHCO_3 (1000), $Q = 1.93$. Using, for Li_2CO_3 (1800), Q_f from Muller's data, gives, for LiHCO_3 (1900), $Q_f = 231.38$.

Li_2CO_3 (c). de Forcrand⁴⁹ measured the heat of solution in water.

LiCH_3O (60 CH_3OH). de Forcrand¹⁶ measured the heat of solution of Li (c) in methyl alcohol.

$\text{LiC}_2\text{H}_3\text{O}_2 \cdot n\text{H}_2\text{O}$ (c). The vapor pressure of the hydrates was measured at various temperatures by Lescoeur.⁶

$\text{LiC}_2\text{H}_5\text{O}$ (60 $\text{C}_2\text{H}_5\text{OH}$). de Forcrand¹⁶ measured the heat of solution of Li (c) in ethyl alcohol.

LiCN (aq.). Varet³ measured the heat of neutralization of LiOH (110) with HCN (110).

Li_2SiO_3 (gls.). Tschernobaeff¹ measured the heat of reaction between SiO_2 and Li_2CO_3 in a bomb using carbon as the auxiliary combustible material.

Li_2SiF_6 (aq.). Truchot² measured the heat of reaction between SiF_4 (g) and 2LiF (c), and between H_2SiF_6 (aq.) and 2LiOH (aq.). His data yield, respectively, for Q_f , Li_2SiF_6 (220), 676.9, and Li_2SiF_6 (1320), 680.9.

Li_2SiF_6 (c). Truchot² measured the heat of solution.

$2\text{LiI} \cdot \text{PbI}_2 \cdot n\text{H}_2\text{O}$ (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the tetrahydrate.

$n\text{LiCl} \cdot \text{ThCl}_4 \cdot m\text{H}_2\text{O}$ (c). Chauvenet² measured the heats of solution of $\text{LiCl} \cdot \text{ThCl}_4 \cdot 8\text{H}_2\text{O}$ (c) and of $2\text{LiCl} \cdot \text{ThCl}_4$ (c).

LiHg_{99} (liq.). Lewis and Keyes² computed the partial molal heat of solution of Li (c) in LiHg_{99} (liq.) from the temperature coefficient of the electromotive force of cells.

LiHg_x (c). Zukowsky¹ measured the heat of solution of Li and its solid amalgams in H_2SO_4 (aq.).

$n\text{LiBr} \cdot \text{HgBr}_2$ (aq.). Varet⁸ measured the heat of mixing, in various proportions, of LiBr (aq.) with HgBr_2 (aq.).

$n\text{LiCN} \cdot \text{Hg}(\text{CN})_2$ (aq.). Varet² measured the heat of mixing of LiCN (aq.) with $\text{Hg}(\text{CN})_2$ (aq.).

$n\text{LiX} \cdot \text{Hg}(\text{CN})_2 (\text{aq.})$. Varet² measured the heat of mixing of $\text{LiCl} (\text{aq.})$ with $\text{Hg}(\text{CN})_2 (\text{aq.})$, $\text{LiBr} (\text{aq.})$ with $\text{Hg}(\text{CN})_2 (\text{aq.})$, and $\text{LiI} (\text{aq.})$ with $\text{Hg}(\text{CN})_2 (\text{aq.})$.

$\text{LiX} \cdot \text{Hg}(\text{CN})_2 \cdot 3\frac{1}{2} \text{H}_2\text{O} (\text{c.})$. Varet² measured the heats of solution of the bromide and the iodide.

$\text{LiX} \cdot n\text{NH}_3 (\text{c.})$. Bonnefoi¹ measured the heats of solution of the mono-, di-, tri-, and tetrammines of LiCl and LiBr , and also the temperature coefficient of their dissociation pressures. Biltz and Hansen¹ measured the temperature coefficient of the dissociation pressures of the amines of LiCl containing 4 and 5 moles of NH_3 ; and of LiI with 1, 2, 3, 4, 5, and $6\frac{1}{2}$ moles of NH_3 ; and of LiI with 1, 2, 3, 4, 5, $5\frac{1}{2}$, and 7 moles of NH_3 . Ephraim⁵ obtained similar but discordant data on $\text{LiI} \cdot 4\text{NH}_3 (\text{c.})$.

$\text{LiX} \cdot n\text{CH}_3\text{NH}_2 (\text{c.})$, $\text{LiX} \cdot n(\text{CH}_3)_2\text{NH} (\text{c.})$, $\text{LiX} \cdot n\text{C}_2\text{H}_5\text{NH}_2 (\text{c.})$. Bonnefoi¹ measured the heats of solution of $\text{LiCl} \cdot n\text{CH}_3\text{NH}_2 (\text{c.})$ with 1, 2, and 3 moles of CH_3NH_2 , of $\text{LiCl} \cdot (\text{CH}_3)_2\text{NH} (\text{c.})$, and of $\text{LiCl} \cdot n\text{C}_2\text{H}_5\text{NH}_2 (\text{c.})$ with 1, 2, and 3 moles of $\text{C}_2\text{H}_5\text{NH}_2$, and also obtained data on the temperature coefficient of the dissociation pressures of $\text{LiCl} \cdot n\text{CH}_3\text{NH}_2 (\text{c.})$ with 1, 2, and 3 moles of CH_3NH_2 , and of $\text{LiCl} \cdot n\text{C}_2\text{H}_5\text{NH}_2 (\text{c.})$, with 1, 2, and 3 moles of $\text{C}_2\text{H}_5\text{NH}_2$. Simon and Glauner¹ measured, at various temperatures, the dissociation pressures of $\text{LiCl} \cdot n\text{CH}_3\text{NH}_2 (\text{c.})$ with 1, 2, 3, and 4 moles of CH_3NH_2 , of $\text{LiBr} \cdot n\text{CH}_3\text{NH}_2 (\text{c.})$ with 1, 2, 3, 4, and 5 moles of CH_3NH_2 , of $\text{LiI} \cdot n\text{CH}_3\text{NH}_2 (\text{c.})$ with 1, 2, 3, and $3\frac{1}{2}$ moles of CH_3NH_2 , of $\text{LiCl} \cdot n(\text{CH}_3)_2\text{NH} (\text{c.})$ with 1, 2, and 3 moles $(\text{CH}_3)_2\text{NH}$, of $\text{LiBr} \cdot n(\text{CH}_3)_2\text{NH} (\text{c.})$ with $\frac{1}{2}$, 1, 2, 3, 4, and 5 moles of $(\text{CH}_3)_2\text{NH}$, and of $\text{LiI} \cdot n(\text{CH}_3)_2\text{NH} (\text{c.})$ with $\frac{1}{2}$, 1, $1\frac{1}{2}$, 2, 3, and 5 moles of $(\text{CH}_3)_2\text{NH}$.

SODIUM

Na (c). Standard state.

Na (liq.). The data on the heat of fusion are: Griffiths,¹ -0.634 ; Rengade,⁵ -0.627 ; Iitaka,¹ -0.598 ; Joannis,² -0.73 ; Bernini,^{1, 2, 3} -0.41 ; Bridgman,² -0.69 .

Na (g). We have calculated the heat of sublimation of sodium to form the monatomic gas from the vapor pressure-temperature data, taking due account of the appreciable amount of Na_2 molecules contained in the actual vapor at equilibrium. The vapor pressure data used are those of Edmonson and Egerton,^{1, 2} Rodebush and Walters,¹ Rodebush,² Rodebush and de Vries,¹ Rodebush and Henry,¹ Haber and Zisch,¹ Ladenberg and Minkowski,¹ and Gibhart.¹ See also Kroner,¹ Hackspill,¹ van Laar,⁹ and Simon and Zeidler.¹ Our value for the heat of sublimation, $\text{Na} (\text{c}) = \text{Na} (\text{g})$, is -25.9 at 18° . Sherman¹ calculated -25.8 .

The values for the energy states of the sodium atom are taken from Fowler,³ Bacher and Goudsmit,¹ and Sodergvist.¹

$\text{Na}_2 (\text{g})$. Loomis and Nusbaum³ and Nusbaum and Loomis¹ reported the energy of dissociation, $\text{Na}_2 (\text{g}) = 2 \text{Na} (\text{g})$, with each substance in its normal state, to be 0.76 ± 0.02 volt-electrons. The values for the energy

states of gaseous diatomic sodium are from Mulliken,⁶ Loomis,¹ Loomis and Wood,¹ Fredrichson and Watson,¹ Fredrichson,¹ Wiezel and Kulp,¹ and Kimura and Uchida.¹

NaOH (aq.). The heat of solution of Na (c) in water was measured by Thomsen,¹⁵ Joannis,² Rengade,¹ and Hagen and Sieverts.¹ Their recomputed data give, respectively, for $\text{Na (c)} + \text{H}_2\text{O (liq.)} = \text{NaOH (200)} + \frac{1}{2} \text{H}_2 \text{ (g)}$, the following values, for Q : 43.56 ± 0.02 , 43.08 ± 0.20 , 44.00 ± 0.23 , and 44.42 ± 0.21 . Selecting 43.7 as the best value, we have obtained, for NaOH (100) , $Qf = 112.1$. The existing data on the heat of dilution of NaOH (aq.) from 25 to 3200 H_2O (Richards and Rowe,² Pratt,¹ Richards and Gucker¹) were reviewed by Rossini,⁵ who gave values from 25 to ∞ H_2O . For the concentrated region, the data of Thomsen,¹⁵ Berthelot,²⁰ Sabatier,¹ de Forcrand,³⁵ Richards and Rowe,² and Richards and Hall² have been utilized to obtain values from 25 to 3 H_2O .

$\text{Na}^+(\infty)$. The foregoing data give, for $\text{Na}^+(\infty) + \text{OH}^-(\infty)$, $Qf = 112.139$; whence, for $\text{Na}^+(\infty)$, $Qf = 57.479$. Allmand and Pollock,¹ from measurements of the electromotive force of cells at various temperatures, found, for $\text{Na (c)} + \text{HgCl (c)} = \text{NaCl (c)} + \text{Hg (liq.)}$, $Q = 66.74$. Using our values for the heats of formation of HgCl (c) and $\text{Cl}^-(\infty)$, and the heat of solution and dilution of NaCl , these data give, for $\text{Na}^+(\infty)$, $Qf = 57.48$.

NaOH (c, II). The data on the heat of solution of NaOH (c, II) yield the following values for S_{200} : Thomsen,¹⁵ 9.96; Berthelot,²⁰ 10.01; de Forcrand,³⁵ 10.18.

$\text{NaOH} \cdot n\text{H}_2\text{O (c)}$. de Forcrand³⁵ measured the heats of solution of $\text{NaOH} \cdot \frac{1}{2} \text{H}_2\text{O (c)}$, $\text{NaOH} \cdot \frac{2}{3} \text{H}_2\text{O (c)}$, $\text{NaOH} \cdot \frac{3}{4} \text{H}_2\text{O (c)}$, and $\text{NaOH} \cdot \text{H}_2\text{O (c)}$; Berthelot²⁰ that of $\text{NaOH} \cdot 0.76 \text{H}_2\text{O (c)}$; and Pickering¹² that of $\text{NaOH} \cdot \text{H}_2\text{O (c)}$. The values calculated from the data of de Forcrand are taken as the best. For $\text{NaOH} \cdot \text{H}_2\text{O (c)}$, the following values for S_{200} were computed: de Forcrand,³⁵ 5.09; Pickering,¹² 5.08. See also Shibata.¹

NaOH (c, I). Hevesy¹ measured the heat of transition.

$\text{Na}_2\text{O (c)}$. The data of Rengade³ and Matsiu and Nakata¹ yield, respectively, for S_{200} , 56.48 and 56.20. We have taken the average as the best value. Beketoff¹ found $S = 55$ to 56.

$\text{Na}_3\text{O (c)}$. de Forcrand²⁵ measured the heat of solution.

$\text{Na}_2\text{O}_2 \text{ (c)}$. de Forcrand²⁵ measured the heat of solution in HCl (aq.) .

$\text{NaHO}_2 \text{ (aq.)}$. Joyner¹ measured the heat of mixing $\text{NaHO}_2 \text{ (aq.)}$ with $\text{HNO}_3 \text{ (aq.)}$

NaH (c) . de Forcrand⁴³ measured the heat of solution of NaH (c) . Hagen and Sieverts¹ measured the heats of solution of Na (c) and of NaH (c) . These data yield, respectively, for NaH (c) , $Qf = 17.9$, and 12.7 ± 0.3 . The dissociation pressure data of Keyes¹ yield $Qf = 14.4$. From the dissociation pressure data of Troost and Hautefeuille,⁸ Moutier¹ calculated $Qf = 13$. See also Zhukov.²

NaH (g) . The value for the energy of dissociation of normal gaseous NaH into normal gaseous Na and H atoms is from Hori.⁶ See also Mulli-

ken.⁶ The values for the energy states of gaseous NaH are from Hori.⁶ See also Mulliken⁶ and Jevons.¹

NaF (aq.). Thomsen¹⁵ and Mulert¹ measured the heat of neutralization of HF (aq.) with NaOH (aq.). Their data yield respectively: NaF (400), $Q_f = 135.50$; NaF (70), $Q_f = 138.1$. We have selected Thomsen's value, since it gives a more concordant value for $F(-\infty)$. We have estimated the heat of dilution of NaF (aq.) in the range 100 to ∞ H₂O.

NaF (c). The heat of solution was measured by Guntz.¹

NaF (liq.). Plato² measured the heat of fusion.

NaF (g). The vapor pressure data of von Wartenberg and Schulz¹ and Ruff, Schmidt, and Mugdan¹ yield $V = -57^{1300}$.

NaHF₂ (aq.). Thomsen¹⁵ measured the heat of mixing NaF(200) with HF(200).

NaHF₂ (c). The data of Guntz¹ and de Forcrand⁶⁰ yield identical values for S_{400} .

NaCl (aq.). The heat of neutralization of NaOH (aq.) with HCl (aq.) was measured by Hess,⁵ Andrews,^{2, 7, 11} Favre and Silbermann,³ Favre,³ Berthelot,⁴ Thomsen,¹⁵ Muller,¹ von Steinwehr,¹ Mathews,¹ Mathews and Germann,¹ Ellingson,¹ Keyes, Gillespie, and Mitsukuri,¹ Richards and Rowe,³ and Gillespie, Lambert, and Gibson.¹ The data of the last two named investigations were recomputed by Rossini,⁶ giving $N = 13.996_{201}$. Biltz and Haase¹ measured the heat of solution of Na (c) in excess HCl(8). The data on the heat of dilution of NaCl (aq.) from 25 to ∞ H₂O, (Pratt,¹ Richards and Rowe,² Lange and Messner,² Lange and Robinson,¹ Thomsen,¹⁵ van Deventer and van der Stadt,¹ Laksonen,² Backlung,¹ Magie,¹ Stearn and Smith¹) were reviewed by Rossini,⁵ who gave values from ∞ to 25 H₂O. For the concentrated region, the data of Wust and Lange,² Lipsett, Johnson, and Maass,¹ Randall and Bisson,¹ Stackelberg,¹ Sandonnini and Gerosa,¹ Scholz,¹ Laksonen,² and Allmand and Pollock¹ have been utilized to obtain values from 25 to 10 H₂O.

NaCl (c). The existing data on the heat of solution have been recomputed to give the following values for S_{200} : Winkelmann,¹ -1.14 ; Berthelot,¹⁰ -1.18 ; Ostwald,² -1.235 ; Berthelot and Ilosvay,¹ -1.153 ; Thomsen,¹⁵ -1.185 ; Pickering,⁷ -1.210 ; Scholz,¹ -1.31 ; Varet,² -1.27 ; Stackelberg,¹ -1.106 ; Varali-Thevenet,¹ -1.225 ; Brönsted,⁴ -1.164 ; Zemczuzny and Rambach,¹ -1.22 ; Randall and Bisson,¹ -1.219 ; Laksonen,² -1.255 ; Sandonnini and Gerosa,¹ -1.240 ; Wust and Lange,² -1.210 ; Lipsett, Johnson, and Maass,¹ -1.206 ; and Cohen and Kooy,¹ -1.203 . We have taken the average of the values of Randall and Bisson, -1.219 , Wust and Lange, -1.210 , Lipsett, Johnson, and Maass, -1.206 , and Cohen and Kooy, -1.203 , obtaining -1.210 ± 0.005 .

NaCl (liq.). The data on the heat of fusion of sodium chloride at its melting point are: Plato,² -7.23 ; Hare,¹ -7.23 ; Zemczuzny and Rambach,¹ -5.7 ; Roth and Bertram,¹ -7.41 .

NaCl (g). Vapor pressure data were given by Fiock and Rodebush,¹ Hackspill and Grandadam,¹ Horiba and Baba,¹ von Wartenberg and

Albrecht,¹ and Ruff and Mugdan.¹ We have selected $V = -43.5$,¹²⁰⁰ whence the heat of sublimation at 18° becomes -57.1 . See also Beutler and Polanyi,¹ Reis,² and van Laar.⁹

NaClO (aq.). Favre,¹ Berthelot,¹⁵¹ Thomsen,¹⁵ and Neumann and Müller² measured the heat of reaction between Cl_2 (g) and NaOH (aq.). Their data yield, respectively, for NaClO (800), $Q_f = 83, 84, 83.28$, and 82.73 . Thomsen¹⁵ and Neumann and Müller² also measured the heat of neutralization of NaOH (aq.) with HClO (aq.), their data yielding, respectively, NaClO (800), $Q_f = 83.40$, and NaClO (400), $Q_f = 83.56$.

NaClO₃ (aq.). Thomsen¹⁵ measured the heat of neutralization of NaOH (aq.) with HClO_3 (aq.). His data give, for NaClO_3 (400), $Q_f = 78.25$. The heat of dilution in the very dilute region was measured at 25° by Lange and Robinson.² We have converted their data to 18° and extrapolated to $200 \text{ H}_2\text{O}$.

NaClO₃ (c). The data of Berthelot² yield $S = -5.1_{300}$, and those of Bronsted,¹⁰ $S = -5.32_{400}$, giving $Q_f = 83.4$ and 83.57 , respectively. From electromotive force measurements over a range of temperatures, Bronsted¹⁰ found, for KCl (c) + NaClO_3 (c) = KClO_3 (c) + NaCl (c), $Q = 1.52$. Taking the other values as known, we have obtained, for NaClO_3 (c), $Q_f = 83.64$.

NaClO₄ (aq.). The data of Berthelot,⁷⁹ who measured the heat of neutralization of HClO_4 (aq.), yield, for NaClO_4 (660), $Q_f = 97.53$. We have estimated the heat of dilution from 400 to $\infty \text{ H}_2\text{O}$.

NaClO₄ (c). Berthelot⁷⁹ measured the heat of solution.

NaBr (aq.). The heat of neutralization of HBr (aq.) with NaOH (aq.) was measured by Berthelot¹⁰ and Richards and Rowe.³ The latter data have been recomputed to give $N = 13.923_{201}$. The heat of dilution of NaBr (aq.) was measured by Wust and Lange,² Lange and Robinson,¹ van Deventer and van der Stadt,² and Dunnington and Hoggard.¹ These data have been utilized to obtain values from ∞ to $6 \text{ H}_2\text{O}$.

NaBr (c). The data on the heat of solution have been recomputed to give the following values for S_{200} : Favre and Valson,² 0.0 ; Berthelot,¹⁰ -0.04 ; Thomsen,¹⁵ -0.19 ; Varet,² -0.58 ; Wust and Lange,² -0.61 .

NaBr (liq.). We have estimated the heat of fusion.

NaBr (g). Vapor pressure data were reported by von Wartenberg and Albrecht¹ and Ruff and Mugdan.¹ See also von Wartenberg and Schulz,¹ van Laar,³ and Beutler and Polanyi.¹ We have calculated $V = -38.8$,¹²⁵⁰ and -53.8 for the heat of sublimation at 18° . Franck, Kuhn, and Rollefson,¹ from the spectral absorption limit, computed $D^* = -91$, for NaBr (g). See also Visser.¹

NaBr · 2 H₂O (c). The data on the heat of solution yield the following values for S_{200} : Favre and Valson,² -4.9 ; Berthelot,¹⁰ -4.31 ; Thomsen,¹⁵ -4.59 .

NaBrO (aq.). Thomsen¹⁵ measured the heat of reaction of Br_2 (g) with 2 NaOH (400). His data yield for NaBrO (aq.), $Q_f = 78.67$. Berthelot's⁸¹ data on the same reaction are apparently uncertain.

NaBrO₃ (aq.). From the ions, we have obtained for NaBrO₃ (∞), $Q_f = 68.68$. The data of Lange and Robinson,² who measured the heat of dilution in the very dilute range of concentration at 25°, have been converted to 18° and extrapolated to 200 H₂O.

NaI (aq.). The heat of neutralization of HBr (aq.) with NaOH (aq.) was measured by Berthelot¹⁰ and Richards and Rowe.³ The latter data have been recomputed, giving $N = 13.855_{201}$. The heat of dilution data of Wust and Lange² and Lange and Robinson,² at 25°, have been used to obtain values at 18° from ∞ to 5 H₂O.

NaI (c). The heat of solution data yield the following values for S_{200} : Favre and Valson,² 1.7(?); Berthelot,¹⁰ 1.552; Thomsen,¹⁵ 1.147; Pickering,⁸ 1.392; Varet,² 1.280; Mosnier,¹ 1.40; and Wust and Lange,² 1.555.

NaI (liq.). We have estimated the heat of fusion.

NaI (g). Vapor pressure data were reported by von Wartenberg and Albrecht¹ and Ruff and Mugdan.¹ We have taken $V = -38.6^{1100}$ and calculated -50.4 for the heat of sublimation at 18°. Sommermeyer¹ calculated, from the spectral absorption limit of sodium iodide vapor, $D^\circ = -70$.

NaI · 2 H₂O (c). The data on the heat of solution yield the following values for S_{200} : Favre and Valson,² $-5.7(?)$; Berthelot,¹⁰ -3.80 ; and Thomsen,¹⁵ -3.98 .

NaI (C₂H₅OH). Pickering⁸ measured the heat of solution of sodium iodide in ethyl alcohol.

NaIO₃ (aq.). From the ions, we have obtained for NaIO₃ (∞), $Q_f = 111.98$. The heat of dilution was measured at 25° by Lange and Robinson.²

Na₂S (aq.). Berthelot¹⁴ measured the heat of neutralization of H₂S (aq.) with 2 NaOH (aq.); Thomsen¹⁵ and Sabatier,¹ that of H₂S (g) with 2 NaOH (aq.). Their data yield for Na₂S(400), $Q_f = 104.98, 105.20$, and 104.98 , respectively. Sabatier¹ also measured the heat of mixing Na₂S (aq.) with 2 HCl (aq.), and of the reaction of Na₂S (aq.) with I₂ (s). These latter data yield $Q_f = 105.3$ and 104.1 , respectively. Sabatier¹ measured the heat of dilution of Na₂S (aq.) from 20 to 400 H₂O. We have estimated the values to infinite dilution.

Na₂S (c). The existing data yield the following values for S_{400} : Sabatier,¹ 15.19; and Rengade and Costeau,¹ 15.5(?).

Na₂S (liq.). Friedrich¹ gave $F = -1.65^{920}$ from the freezing point lowering constant.

Na₂S · n H₂O (c). Sabatier¹ measured the heats of solution of the hydrates with $4\frac{1}{2}$, 5, and 9 moles of H₂O.

NaHS (aq.). Berthelot¹⁴ measured the heat of reaction of NaOH (110) with H₂S(880); Thomsen¹⁵ that of NaHS(400) with NaOH(400); Sabatier¹ that of NaHS(1470) with HCl(110). These data yield the following values for NaHS(400): 61.28, 61.49, 61.32, and 61.75. Sabatier¹

measured the heat of dilution of aqueous NaHS from 4 to 200 H₂O. We have estimated the values to infinite dilution, assuming no dissociation of HS⁻(aq.).

NaHS · nH₂O (c). Sabatier¹ measured the heats of solution of the anhydrous salt and the dihydrate.

NaS_n (aq.). Sabatier¹ measured the heat of reaction of I₂ with Na₂S₂(aq.), Na₂S₃(aq.), and Na₂S₄(aq.), respectively.

Na₂S₄ (c). Sabatier¹ measured the heat of solution.

Na₂SO₃ (aq.). Thomsen¹⁵ measured the heat of reaction of H₂SO₃(400) with 2 NaOH(200); de Forcrand⁴ that of H₂SO₃(220) with 2 NaOH(150), and of Na₂SO₃(550) with 2 HCl(110). These data yield for Na₂SO₃(∞), *Qf* = 263.2, 264.2, and 265.1, respectively. We have estimated the heat of dilution.

Na₂SO₃ · nH₂O (c). de Forcrand⁴ measured the heats of solution of the anhydrous salt and the heptahydrate. Ariei,¹ from vapor pressure data, calculated, for Na₂SO₃(c) + 7 H₂O(liq.) = Na₂SO₃ · 7 H₂O(c), *Q* = 2.67.

NaHSO₃ (aq.). Thomsen,¹⁵ de Forcrand,⁴ and Lindner¹ measured the heat of reaction of NaOH(aq.) with H₂SO₃(aq.). Their data yield the following values for *Qf*: Thomsen, NaHSO₃(600), 206.30; de Forcrand, NaHSO₃(370), 207.12; Lindner, NaHSO₃(600), 206.17; Lindner NaHSO₃(111), 207.15. de Forcrand⁴ also measured the heat of mixing NaHSO₃(aq.) with NaOH(aq.), and of Na₂SO₃(aq.) with H₂SO₃(aq.). These latter data yield for NaHSO₃(500), *Qf* = 205.6 and 206.40.

Na₂SO₄ (aq.). The heat of neutralization of H₂SO₄(aq.) with NaOH(aq.) was measured by Favre and Silbermann,³ Andrews,^{2, 7, 11} Favre,³ Hess,⁵ Thomsen,¹⁵ Berthelot,⁴ Recoura,² Mathews and Germann,¹ Richards and Rowe,⁴ and Thorvaldson, Brown, and Peaker.¹ The data of the last six investigations yield, respectively, for Na₂SO₄(400), *Qf* = 330.69, 330.68, 331.4, 330.1, 331.06, and 331.06. Thomsen¹⁵ measured the heat of mixing 2 NaCl(100) with H₂SO₄(200) and of Na₂SO₄(200) with 2 HCl(100). Subtraction of these heats of reaction gives that for 2 NaCl(100) + H₂SO₄(200) = Na₂SO₄(200) + 2 HCl(100); whence we have obtained the value for Na₂SO₄(200). In another pair of such "double decomposition" experiments, Thomsen¹⁵ used twice the dilutions. His data yield, for Na₂SO₄(400), *Qf* = 330.68 and 331.02. Berthelot⁴ performed similar "double decomposition" experiments, and his data yield, for Na₂SO₄(400), *Qf* = 331.25 from Na⁺, SO₄⁻, H⁺, NO₃⁻, and *Qf* = 331.07, from Na⁺, SO₄⁻, H⁺, Cl⁻. The data of Thomsen,¹⁵ Varali-Thevenet,¹ and Lange and Streeck¹ have been used to obtain values for the heat of dilution of Na₂SO₄(aq.) from ∞ to 50 H₂O.

Na₂SO₄ (c, II). The data on the heat of solution yield the following values for *S*₄₀₀: Thomsen,¹⁵ 0.257; Tilden,² 0.25; Pickering,⁵ -0.09. Other data on the heat of solution, lacking in most cases necessary information as to temperatures and concentration, were reported by Graham,¹ Favre and Valson,² Berthelot,¹⁰ Berthelot and Ilosvay,¹ and Varali-Thevenet.¹ Mixer⁶ measured, in a bomb calorimeter, the heat

of the reaction, $3 \text{Na}_2\text{O}_2 (\text{c}) + \text{S} (\text{c}) = \text{Na}_2\text{SO}_4 (\text{c}) + 2 \text{Na}_2\text{O} (\text{c})$, and his data yield $Q_f = 328.4$. See also Ruff and Friedrich.¹

$\text{Na}_2\text{SO}_4 (\text{c}, \text{I})$. For the heat of transition, see Hullner and Tammann¹ and Hare.¹

$\text{Na}_2\text{SO}_4 (\text{liq.})$. Hare¹ determined the heat of fusion.

$\text{Na}_2\text{SO}_4 \cdot 10 \text{H}_2\text{O} (\text{c})$. The heat of solution data yield the following values for S_{400} : Thomsen,¹⁵ -18.76 ; Tilden,² -18.53 ; Pickering,⁵ -19.15 ; Berthelot,¹⁰ -18.85 ; Favre and Valson,² $-18.9(?)$; Perreu,¹ -18.6 .

$\text{NaHSO}_4 (\text{aq.})$. Thomsen¹⁵ and Berthelot⁶ measured the heat of mixing $\text{Na}_2\text{SO}_4 (200)$ with $\text{H}_2\text{SO}_4 (200)$ to be -1.870 and -2.10 , respectively. Taking -1.90 gives for $\text{NaHSO}_4 (200)$, $Q_f = 270.29$. The data of Thomsen¹⁵ yield values for the heat of dilution from 10 to 800 H_2O .

$\text{NaHSO}_4 (\text{c})$. For S_{200} , the data of Thomsen¹⁵ yield 1.25 and those of Berthelot 1.3.

$\text{NaHSO}_4 \cdot \text{H}_2\text{O} (\text{c})$. Favre⁸ measured the heat of solution.

$\text{Na}_2\text{S}_2\text{O}_5 (\text{aq.})$. We have taken equal to zero the heat of the reaction, $2 \text{HSO}_3^- (\text{aq.}) = \text{S}_2\text{O}_5^{2-} (\text{aq.}) + \text{H}_2\text{O} (\text{liq.})$.

$\text{Na}_2\text{S}_2\text{O}_5 (\text{c})$. de Forcrand⁴ measured the heat of solution in water and in $\text{NaOH} (\text{aq.})$. These data give, for $\text{Na}_2\text{S}_2\text{O}_5 (\text{c})$, $Q_f = 349.2$ and 348.8, respectively.

$\text{Na}_2\text{S}_2\text{O}_3 (\text{aq.})$. Thomsen¹⁵ measured the heat of reaction of $\text{Na}_2\text{S}_2\text{O}_3 (\text{aq.})$ with $\text{HClO} (\text{aq.})$; Berthelot¹⁰³ that of $\text{Na}_2\text{S}_2\text{O}_3 (\text{aq.})$ with $\text{KBr}_3 (\text{aq.})$. Their data yield, respectively, for $\text{Na}_2\text{S}_2\text{O}_3 (\text{aq.})$, $Q_f = 260.5$ and 263.7. Bichowsky³ measured the heat of mixing aqueous CaS_2O_3 with concentrated aqueous HCl , forming rhombic sulfur. Assuming the reaction, $\text{S}_2\text{O}_3^{2-} (\text{aq.}) = \text{SO}_3^{2-} (\text{aq.}) + \text{S} (\text{c, rhombic})$, his data, $Q = -3.94$, yield, for $\text{S}_2\text{O}_3^{2-} (\text{aq.})$, $Q_f = 145.1$; whence, for $\text{Na}_2\text{S}_2\text{O}_3 (\text{aq.})$ $Q_f = 260.1$. Thomsen measured the heat of mixing aqueous $\text{Na}_2\text{S}_2\text{O}_3$ with aqueous HCl to be -2.2 . Assuming the same reaction as before we have obtained, for $\text{Na}_2\text{S}_2\text{O}_3 (\text{aq.})$, $Q_f = 261.8$.

$\text{Na}_2\text{S}_2\text{O}_3 (\text{c})$. The data of Berthelot⁹² yield $S = 2.0_{440}$; Fogh¹ found $S = 1.4$.

$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5 \text{H}_2\text{O} (\text{c}, \alpha)$. The data of Thomsen¹⁵ and Berthelot¹⁰⁸ yield, for S_{400} , -11.33 and -10.6 , respectively.

$\text{Na}_2\text{S}_2\text{O}_3 \cdot 5 \text{H}_2\text{O} (\text{c}, \beta)$. Muller¹¹ measured the heat of solidification of the supercooled liquid, and found, for the α and β forms of the solid, respectively, $F^{17.5} = -9.3$ and -8.0 ; whence, for the α to β transition, $T = -1.3^{17.5}$.

$\text{Na}_2\text{S}_2\text{O}_3 (5)$. Q_f for this substance is obtained from the foregoing data.

$\text{Na}_2\text{S}_2\text{O}_6 (\text{aq.})$. The value for this substance is obtained from those for the ions.

$\text{Na}_2\text{S}_2\text{O}_6 \cdot n \text{H}_2\text{O} (\text{c})$. Thomsen¹⁵ measured the heats of solution of the anhydrous salt and the dihydrate.

$\text{Na}_2\text{S}_3\text{O}_6$ (aq.). Berthelot¹⁰⁸ measured the heat of reaction of $\text{Na}_2\text{S}_3\text{O}_6$ (aq.) with KBr_3 (aq.). His data yield $Qf=394.6$.

$\text{Na}_2\text{S}_3\text{O}_6 \cdot 3\text{H}_2\text{O}$ (c). Berthelot¹⁰⁸ measured the heat of solution.

$\text{Na}_2\text{S}_4\text{O}_6$ (aq.). Thomsen¹⁵ and Berthelot¹⁰⁸ measured the heat of the reaction, $2\text{Na}_2\text{S}_2\text{O}_8$ (aq.) + I_2 (c) = $(2\text{NaI} + \text{Na}_2\text{S}_4\text{O}_6)$ (aq.). Their data yield, for $\text{Na}_2\text{S}_4\text{O}_6$ (aq.), $Qf=387.3$ and 388.1 , respectively. Berthelot¹⁰⁸ also measured the heat of reaction between $\text{Na}_2\text{S}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$ (c) and KBr_3 (aq.) (with the formation of sulfate), and the heat of solution of the dihydrate; and from these data we have obtained, for $\text{Na}_2\text{S}_4\text{O}_6$ (aq.), $Qf=387.2$.

$\text{Na}_2\text{S}_4\text{O}_6 \cdot 2\text{H}_2\text{O}$ (c). Berthelot¹⁰⁸ measured the heat of solution.

$\text{NaI} \cdot n\text{SO}_2$ (c). From measurement of the dissociation pressure at various temperatures, Ephraim and Kornblum¹ found for $n=4$, $D=-9.63$, and for $n=2$, $D=-10.0$; de Forcrand and Taboury,¹ found for $n=2$, $D=-10.25$.

Na_2Se (aq.). Fabre¹ measured the heat of neutralization of NaOH (220) with H_2Se (g) and $\text{H}_2\text{Se}(4000)$, respectively. His data yield for Qf , $\text{Na}_2\text{Se}(440)$, 77.12 ; $\text{Na}_2\text{Se}(4400)$, 78.64 .

$\text{Na}_2\text{Se} \cdot n\text{H}_2\text{O}$ (c). Fabre¹ measured the heats of solution of the anhydrous salt and of the hydrates with $4\frac{1}{2}$, 9 , and 16 moles of H_2O .

NaHSe (aq.). Fabre¹ measured the heat of the reaction of H_2Se (aq.) with NaOH (aq.), and of NaHSe (aq.) with NaOH (aq.). These data yield, respectively, $Qf=31.24$ and 30.81 , for NaHSe (aq.).

Na_2SeO_3 (aq.). Thomsen¹⁵ measured the heat of neutralization of H_2SeO_3 (aq.) with NaOH (aq.). His data yield, for $\text{Na}_2\text{SeO}_3(800)$, $Qf=238.22$.

NaHSeO_3 (aq.). Thomsen¹⁵ found $Q=14.76$ for the reaction, NaOH (400) + $\text{H}_2\text{SeO}_3(800) = \text{NaHSeO}_3(1200) + \text{H}_2\text{O}$ (liq.).

Na_2SeO_4 (aq.). The data of Thomsen¹⁵ yield $N=30.41_{800}$, and those of Metzner,² $N=31.05_{440}$; whence we have computed, for $\text{Na}_2\text{SeO}_4(800)$, $Qf=260.99$ and for $\text{Na}_2\text{SeO}_4(440)$, $Qf=261.41$.

NaHSeO_4 (aq.). Thomsen¹⁵ and Metzner² measured the heat of mixing Na_2SeO_4 (aq.) with H_2SeO_4 (aq.). Their data yield, respectively, $\text{NaHSeO}_4(400)$ $Qf=201.72$ and $\text{NaHSeO}_4(220)$, $Qf=201.79$.

Na_2SeO_4 (c). Mixer¹⁰ measured, in a bomb calorimeter, the heat of reaction between amorphous Se and Na_2O_2 to be 95.9 .

Na_2TeO_4 (c). As for the foregoing, Mixer¹⁰ found 149.7 .

NaNO_3 (aq.). The heat of neutralization of NaOH (aq.) with HNO_3 (aq.) was measured by Hess,⁶ Andrews,¹¹ Favre and Silbermann,³ Favre,³ Thomsen,¹⁵ Berthelot,⁴ Mathews and Germann,¹ and Richards and Rowe.³ The accurate data of Richards and Rowe were recomputed by Rossini,⁶ giving $N=13.929_{201}$. The data on the heat of dilution of NaNO_3 from infinite dilution to $25\text{H}_2\text{O}$, (Pratt,¹ Richards and Rowe,² Nernst and Naude,¹ Lange and Robinson²) were reviewed by Rossini,⁵ who gave values from ∞ to $25\text{H}_2\text{O}$. The data of Stahlberg,¹ Stackelberg,¹ and van Deventer and van der Stadt¹ have been utilized to obtain values from

25 to 5 H₂O. Other data on the heat of dilution were given by Bishop,¹ Rümelin,¹ and Mondain-Monval.³

NaNO₃ (c). The existing data on the heat of solution have been recomputed to give the following values for S_{200} : Winkelmann,¹ -4.91; Berthelot,^{10, 131} -4.83; Tilden,² -4.91; Zawidski and Schagger,¹ -5.02; Thomsen,¹⁵ -5.03; Scholz,¹ -5.05; Stackelberg,¹ -5.04; Varali-Thevenit,¹ -4.84; Haigh,¹ -4.95; and Mondain-Monval,³ -4.86. The average of these values is -4.94 ± 0.07 . Brönsted,¹⁰ by measuring the electromotive force of cells at various temperatures, found, for KCl (c) + NaNO₃ (c) = NaCl (c) + KNO₃ (c), $Q = 0.340$. Anticipating the values for KCl (c) and KNO₃ (c), we have computed for NaNO₃ (c), $Q_f = 111.72$. This corresponds to $S = -4.965_{200}$.

NaNO₂ (c). The data of Matignon and Marchal³ and Swietoslawski⁶ yield identical values for the heat of solution.

NaNH₂ (c). de Forcrand²⁴ measured the heat of solution in water.

NaNH₃ (c). Joannis³ found $D = -5.19_{20}$

NaX · nNH₃ (c). Joannis⁶ measured the temperature coefficient of the dissociation pressure of NaCl · 5 NH₃ (c); Biltz and Hansen¹ measured those of NaCl · 5 NH₃ (c), NaBr · 5½ NH₃ (c), NaBr · 5¾ NH₃ (c), NaI · 4½ NH₃ (c), and NaI · 6 NH₃ (c).

Na₂SO₄ · (NH₄)₂SO₄ · H₂O (c). Matignon and Meyer¹ measured the heat of solution.

NaPO₃ (aq.). Thomsen¹⁵ and Giran¹ measured the heat of neutralization of HPO₃ (aq.) with NaOH (aq.). Their data give, respectively, NaPO₃ (600), $Q_f = 292.67$, and NaPO₃ (aq.), $Q_f = 293.08$.

NaPO₃ (c). Giran¹ measured the heat of solution.

Na_nH_{3-n}PO₃ (aq.). Thomsen¹ measured the heat of mixing H₃PO₃ (400) with 1, 2, and 3 moles of NaOH (200), respectively, forming NaH₂PO₃ (600), Na₂HPO₃ (800), and Na₃PO₃ (1000).

NaH₂PO₃ · nH₂O (c). Amat¹ measured the heats of solution of NaH₂PO₃ (c) and NaH₂PO₃ · 2½ H₂O (c).

Na₂HPO₃ · nH₂O (c). Amat¹ measured the heats of solution of the anhydrous salt and the pentahydrate.

Na_nH_{2-n}PO₂ (aq.). Thomsen¹⁵ measured the heat of mixing H₃PO₂ (250) with 1 and 2 moles of NaOH (200), respectively.

Na₃PO₄ · 12 H₂O (c). Joly⁴ measured the heat of solution.

Na₃PO₄ (c). The data of Mixter,⁹ who measured the heat of reaction between 1½ Na₂O (c) and ½ P₂O₅ (c), in a bomb calorimeter, yield $Q_f = 446$. We have obtained, by estimating the heat of dehydration of the dodecahydrate, $Q_f = 457$.

Na₃PO₄ (aq.). The data of Thomsen¹⁵ and Berthelot and Louguinine³ yield, respectively, $N = 34.10_{903}$ and $N = 33.45_{663}$; whence, for Na₃PO₄ (800), we have computed $Q_f = 471.54$ and 470.53. Berthelot and Louguinine³ measured the heat of dilution from 330 to 1980 H₂O.

NaH₂PO₄ (aq.). Thomsen¹⁵ and Berthelot and Louguinine³ measured the heat of mixing H₃PO₄ (aq.) with NaOH (aq.). Their data yield,

respectively, $\text{NaH}_2\text{PO}_4(300)$, $Q_f = 364.64$, and $\text{NaH}_2\text{PO}_4(440)$, $Q_f = 364.68$. Berthelot and Louguinine³ measured the heat of mixing $\text{NaH}_2\text{PO}_4(440)$ with $\text{HCl}(110)$ and of $\text{H}_3\text{PO}_4(440)$ with $\text{NaCl}(110)$, their data yielding, for $\text{NaH}_2\text{PO}_4(440)$, $Q_f = 365.03$.

$\text{Na}_2\text{HPO}_4(\text{aq.})$. Thomsen¹⁵ and Berthelot and Louguinine³ measured the heat of mixing $\text{H}_3\text{PO}_4(\text{aq.})$ with $2\text{NaOH}(\text{aq.})$; Berthelot and Louguinine³ measured the heat of mixing $\text{Na}_2\text{HPO}_4(440)$ with $\text{NaOH}(\text{aq.})$. These data yield, respectively, for $\text{Na}_2\text{HPO}_4(400)$, $Q_f = 420.81$, 419.93 , and 420.43 . Berthelot and Louguinine³ measured the heat of dilution of $\text{Na}_2\text{HPO}_4(\text{aq.})$ from 220 to $880\text{H}_2\text{O}$.

$\text{Na}_2\text{HPO}_4 \cdot n\text{H}_2\text{O}(\text{c.})$. Thomsen¹⁵ and Pfaundler² measured the heats of solution of the anhydrous salt and the hydrates with 7 and 12 moles of H_2O . Thomsen¹⁵ also measured that of the dihydrate. Their data yield for S_{400} the following respective values, for Thomsen and Pfaundler: for $\text{Na}_2\text{HPO}_4(\text{c.})$, 5.65, 5.37; dihydrate, -0.38 , . . . ; heptahydrate, -11.60 , -11.38 ; dodecahydrate, -22.74 , -22.53 . See also Perreu.¹ Muller-Erzbach⁴ measured the temperature-dissociation pressure relationship for the heptahydrate.

$\text{NaH}_3\text{P}_2\text{O}_7(\text{aq.})$. Thomsen¹⁵ and Giran¹ found, respectively, $\text{NaOH}(400) + \text{H}_4\text{P}_2\text{O}_7(800)$, $N = 14.38$; $\text{NaOH}(\text{aq.}) + \text{H}_4\text{P}_2\text{O}_7(\text{aq.})$, $N = 15.29$.⁷

$\text{NaH}_3\text{P}_2\text{O}_7 \cdot n\text{H}_2\text{O}(\text{c.})$. Giran¹ measured the heats of solution of the anhydrous salt and the monohydrate.

$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7(\text{aq.})$. Thomsen¹⁵ and Giran¹ found, respectively, $2\text{NaOH}(200) + \text{H}_4\text{P}_2\text{O}_7(800)$, $N = 28.64^{17.5}$; $2\text{NaOH}(\text{aq.}) + \text{H}_4\text{P}_2\text{O}_7(\text{aq.})$, $N = 29.94$.⁷ Favre and Silbermann³ also measured this heat of neutralization.

$\text{Na}_2\text{H}_2\text{P}_2\text{O}_7 \cdot n\text{H}_2\text{O}(\text{c.})$. Giran¹ measured the heats of solution of the anhydrous salt and the hexahydrate.

$\text{Na}_3\text{HP}_2\text{O}_7(\text{aq.})$. Giran¹ found $N = 43.05$.⁷

$\text{Na}_3\text{HP}_2\text{O}_7 \cdot n\text{H}_2\text{O}(\text{c.})$. Giran¹ measured the heats of solution of the anhydrous salt and the mono- and hexahydrates.

$\text{Na}_4\text{P}_2\text{O}_7(\text{aq.})$. Thomsen¹⁵ found $N = 52.74_{1600}$; Giran,¹ $N = 50.91$.⁷

$\text{Na}_4\text{P}_2\text{O}_7 \cdot n\text{H}_2\text{O}(\text{c.})$. Thomsen¹⁵ measured the heats of solution of the anhydrous salt and the decahydrate.

$\text{Na}_2\text{H}_2\text{P}_2\text{O}_5(\text{c.})$. Amat¹ measured the heats of solution, in aqueous H_2SO_4 , of $\text{Na}_2\text{H}_2\text{P}_2\text{O}_5(\text{c.})$ and of $2\text{NaH}_3\text{PO}_3(\text{c.})$. The difference yields, for $\text{Na}_2\text{H}_2\text{P}_2\text{O}_5(\text{c.}) + \text{H}_2\text{O}(\text{liq.}) = 2\text{NaH}_2\text{PO}_3(\text{c.})$, $Q = 4.80$.

$\text{Na}_2\text{H}_2\text{P}_2\text{O}_5(\text{aq.})$. Amat¹ measured the heat of solution.

$\text{Na}_n\text{H}_{4-n}\text{P}_2\text{O}_6(\text{aq.})$. Joly² measured the heat of mixing $\text{H}_4\text{P}_2\text{O}_6(330)$ with 1, 2, 3, and 4 moles of $\text{NaOH}(220)$, respectively.

$\text{NaNH}_4\text{HPO}_4(\text{aq.})$. Berthelot and Louguinine³ measured the heat of mixing $\text{NaH}_2\text{PO}_4(440)$ with $\text{NH}_3(110)$.

$\text{Na}(\text{NH}_4)_2\text{PO}_4(\text{aq.})$. Berthelot and Louguinine³ measured the heat of mixing $\text{NaNH}_4\text{HPO}_4(550)$ with $\text{NH}_3(110)$.

$\text{Na}_2\text{NH}_4\text{PO}_4(\text{aq.})$. Berthelot¹⁴⁶ measured the heat of mixing $\text{Na}_2\text{HPO}_4(440)$ with $\text{NH}_3(110)$.

$\text{NaNH}_4\text{HPO}_4 \cdot 4 \text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{Na}_n\text{H}_{3-n}\text{AsO}_4$ (aq.). Thomsen¹⁵ measured the heat of mixing H_3AsO_4 (200) with 1, 2, and 3 moles of NaOH (100), respectively.

$\text{Na}_3\text{AsO}_4 \cdot 12 \text{H}_2\text{O}$ (c). Joly⁴ measured the heat of solution.

Na_3AsO_4 (c). The data of Mixer,⁹ who measured in a bomb calorimeter the heat of reaction between As (c) and $2\frac{1}{2} \text{Na}_2\text{O}_2$ (c), yield $Qf=361$. By estimating the heat of dehydration of the dodecahydrate, we have obtained $Qf=366$.

$\text{Na}_n\text{H}_{3-n}\text{AsO}_3$ (aq.). Thomsen¹⁵ measured the heat of mixing of H_3AsO_3 (200) with 1, 2, and 3 moles of NaOH (aq.), respectively.

Na_3SbO_4 (c). The data of Mixer⁹ on the reaction of Sb (c) with $2\frac{1}{2} \text{Na}_2\text{O}_2$ (c) yield $Qf=349$.

Na_3SbO_4 (aq.). We have estimated $S=11$.

$3 \text{Na}_2\text{S} \cdot \text{Sb}_2\text{S}_3$ (aq.). Berthelot⁹⁰ measured the heat of reaction of $3 \text{Na}_2\text{S} \cdot \text{Sb}_2\text{S}_3$ (aq.) with 6HCl (aq.).

Na_3BiO_4 (c). The data of Mixer⁹ yield $Qf=284$.

Na_2C_2 (c). de Forcrand²³ measured the heat of solution of Na_2C_2 (c) in H_2SO_4 (aq.); Matignon¹⁶ that in HCl (aq.). Their data yield, respectively, $Qf=-4.4$ and -4.06 .

NaHC_2 (c). Matignon¹⁶ measured the heat of solution in water and in HCl (aq.). His data yield, respectively, $Qf=-25.19$ and -25.05 .

Na_2CO_3 (aq.). Berthelot⁴ and Thomsen¹⁵ measured the heat of reaction of CO_2 (aq.) with 2NaOH (aq.); Muller¹ that of Na_2CO_3 (aq.) with 2HCl (aq.). Their data yield, respectively, for Na_2CO_3 (200), $Qf=276.0$, 276.24 , and 275.7 . Berthelot⁴ performed some "double decomposition" experiments, and his data yield the following values for Na_2CO_3 (200): from Na^+ , CO_3^{--} , H^+ , $\text{C}_2\text{H}_3\text{O}_2^-$, 276.1 ; from Na^+ , CO_3^{--} , H^+ , SO_4^{--} , 267.4 ; and from Na^+ , CO_3^{--} , H^+ , NO_3^- , 276.8 . Data on the heat of dilution were reported by Thomsen,¹⁵ Perreu,² and Laksonen.¹ These data covered the range as dilute as 200 H_2O . Values to infinite dilution have been estimated. See also Swallow and Alty.¹

Na_2CO_3 (c, II). The data on the heat of solution have been recomputed to give the following values for S_{200} : Favre and Valson,² ?; Berthelot,¹⁰ 6.0 ; Ostwald,¹ 5.80 ; Berthelot and Ilosvay,¹ 5.8 ; Tilden,² 5.74 ; Thomsen,¹⁵ 5.88 ; Pickering,⁷ 5.70 ; Donnan and Hope,¹ 5.85 . See also Swallow and Alty.¹

Na_2CO_3 (c, I). Doelter¹ quoted Wegscheider¹ as giving $T=0.4 \rightarrow \pi^{450}$.

Na_2CO_3 (liq.). Sackur¹ determined the heat of fusion from freezing point lowering data.

$\text{Na}_2\text{CO}_3 \cdot \text{H}_2\text{O}$ (c). For S_{200} , the data of Thomsen¹⁵ yield 2.50 , those of Donnan and Hope¹ 1.95 . The dissociation pressure data of Caven and Sand¹ give $Qf=341.6$.

$\text{Na}_2\text{CO}_3 \cdot 7 \text{H}_2\text{O}$ (c). For S_{200} , the data of Thomsen¹⁵ yield -10.50 , those of Donnan and Hope¹ -10.55 .

$\text{Na}_2\text{CO}_3 \cdot 10 \text{H}_2\text{O}$ (c). The heat of solution data yield the following values for S_{200} : Favre and Valson,² ?; Tilden,² -14.82 ; Thomsen,¹⁵

—15.91; Pickering,⁷ —15.91; Donnan and Hope,¹ —15.25; and Perreu,¹ —16.0.

NaHCO₃ (aq.). Berthelot⁴ measured the heat of mixing CO₂(1600) with NaOH(110); Thomsen¹⁵ that of NaHCO₃(200) with NaOH(200); Muller¹ that of NaHCO₃(1000) with HCl(90). Their data yield, respectively, NaHCO₃(1700), $Q_f=222.41$, NaHCO₃(200), $Q_f=222.67$, and NaHCO₃(1000), $Q_f=222.0$.

NaHCO₃ (c). The data of Berthelot¹⁰ yield $S=-4.1_{300}$, whence $Q_f=226.4$. The dissociation pressure data of Caven and Sand¹ yield the same value.

Na₂C₂O₄ (aq.). The heat of neutralization of aqueous oxalic acid with aqueous NaOH was measured by Berthelot⁷ and Thomsen.¹⁵ Their data yield, respectively, Na₂C₂O₄ (aq.), $Q_f=310.92$, and Na₂C₂O₄(600), $Q_f=310.58$. Berthelot⁷ also performed 2 pairs of "double decomposition" experiments, his data yielding for Na₂C₂O₄(220), $Q_f=311.42$ from Na⁺, C₂O₄²⁻, H⁺, SO₄²⁻, and $Q_f=311.30$ from Na⁺, C₂O₄²⁻, H⁺, C₂H₃O₂⁻. Roth and Eymann¹ measured the heat of neutralization of aqueous NaOH with solid oxalic acid containing 26.7% of H₂O, and the heat of solution of the latter. Their data yield for Na₂C₂O₄(1120), $Q_f=310.39$.

Na₂C₂O₄ (c). Berthelot¹⁰ measured the heat of solution.

NaHC₂O₄ (aq.). Berthelot⁶ measured the heat of mixing Na₂C₂O₄(220) with H₂C₂O₄(220); Berthelot⁷ and Thomsen¹⁵ that of mixing H₂C₂O₄ (aq.) with NaOH (aq.). Their data yield, respectively, NaHC₂O₄(400), $Q_f=252.5$, NaHC₂O₄(400), $Q_f=252.43$, and NaHC₂O₄(220), $Q_f=252.50$.

NaHC₂O₄ · nH₂O (c). Berthelot^{10, 131} measured the heat of solution of the anhydrous salt and its monohydrate.

NaCHO₂ (aq.). Thomsen¹⁵ measured the heat of neutralization of aqueous formic acid with aqueous NaOH; Berthelot⁷ performed 2 pairs of "double decomposition" experiments involving H⁺, Cl⁻, Na⁺, CHO₂⁻. Their data yield, respectively, NaCHO₂(400), $Q_f=157.29$, NaCHO₂(165), $Q_f=157.25$, and NaCHO₂(110), $Q_f=157.19$.

NaCHO₂ (c). Berthelot¹⁰ measured the heat of solution of sodium formate.

NaC₂H₃O₂ (aq.). The heat of neutralization of aqueous acetic acid with aqueous NaOH was measured by Berthelot,⁷ Thomsen,¹⁵ and Richards and Mair.¹ These data yield, respectively, for NaC₂H₃O₂(200), $Q_f=175.38$, 175.08, and 175.237. Data on the heat of dilution were reported by Berthelot⁵ and Thomsen.¹⁵ Richards and Gucker¹ measured the heat of dilution in the range 25 to 1600 H₂O. We have extrapolated these data to infinite dilution, and, using the data of Gnesotto and Fabris,¹ who obtained a value for the heat of fusion of NaC₂H₃O₂ · 3 H₂O (c), we have extended the values to 3 H₂O.

NaC₂H₃O₂ (c). The data on the heat of solution of sodium acetate yield the following values for S_{200} : Berthelot,^{7, 131} 4.0; Thomsen,¹⁵ 3.88; and Pickering,⁷ 3.95.

$\text{NaC}_2\text{H}_3\text{O}_2 \cdot 3 \text{H}_2\text{O}$ (c). The heat of solution data yield the following values for S_{200} : Berthelot,^{7, 131} -4.61 ; Thomsen,¹⁵ -4.86 ; Pickering,⁷ -4.77 ; and Calvet,¹ -4.72 .

$\text{NaC}_2\text{H}_3\text{O}_2(\text{C}_2\text{H}_5\text{OH})$. Pickering⁸ measured the heat of solution of sodium acetate in ethyl alcohol.

$\text{NaCH}_3\text{O}(\text{CH}_3\text{OH})$, $\text{NaC}_2\text{H}_5\text{O}(\text{C}_2\text{H}_5\text{OH})$. de Forcrand¹⁶ measured the heat of solution of Na (c) in methyl alcohol and in ethyl alcohol. See also Cavalier.¹

$\text{NaC}_2\text{H}_3\text{O}_3$ (aq.). de Forcrand³ measured the heat of neutralization of aqueous glycollic acid.

$\text{NaC}_2\text{H}_3\text{O}_3 \cdot n\text{H}_2\text{O}$ (c). de Forcrand³ measured the heats of solution of the anhydrous salt, the hemihydrate, and the dihydrate of sodium glycolate.

$\text{NaC}_2\text{H}_3\text{O}_3 \cdot \text{HC}_2\text{H}_3\text{O}_3$ (c). de Forcrand³ measured the heat of solution of sodium acid glycolate.

$\text{NaC}_2\text{H}_3\text{O}_4$ (aq.). de Forcrand³ measured the heat of neutralization to form sodium glyoxylate.

$\text{NaC}_2\text{H}_3\text{O}_4$ (c). de Forcrand¹⁷ measured the heat of solution of sodium glyoxylate.

$\text{NaC}_2\text{H}_5\text{O}_2$ (aq.). de Forcrand^{6a} measured the heat of solution of liquid ethylene glycol in aqueous NaOH.

$\text{NaC}_2\text{H}_5\text{O}_2$ (c). de Forcrand^{6a} measured the heat of solution of sodium glycol.

$\text{NaC}_2\text{H}_5\text{O}_2 \cdot \text{C}_2\text{H}_6\text{O}_2$ (c). de Forcrand^{6a} measured the heat of solution of sodium glycol-glycol.

$\text{NaC}_2\text{H}_5\text{O}_2 \cdot \text{CH}_3\text{OH}$ (c). de Forcrand^{6a} measured the heat of solution of sodium glycol-methanol.

$\text{NaC}_2\text{H}_5\text{O}_2 \cdot \text{C}_2\text{H}_5\text{OH}$ (c). de Forcrand^{6a} measured the heat of solution of sodium glycol-ethanol.

$\text{NaC}_2\text{H}_5\text{SO}_4$ (aq.). Thomsen¹⁵ measured the heat of the reaction, $\text{Na}_2\text{SO}_4(400) + \text{Ba}(\text{C}_2\text{H}_5\text{SO}_4)_2(800) = \text{BaSO}_4(\text{c}) + 2 \text{NaC}_2\text{H}_5\text{SO}_4(600)$.

$\text{Na}_2\text{S}_2\text{O}_5 \cdot \text{C}_2\text{H}_2\text{O}_2 \cdot 2 \text{H}_2\text{O}$ (c). de Forcrand³ measured the heat of solution.

NaCN (aq.). The data of Thomsen¹⁵ yield $N=2.75_{200}$.

$\text{NaCN} \cdot n\text{H}_2\text{O}$ (c). Joannis¹ measured the heat of solution of the anhydrous salt, the hemihydrate, and the dihydrate.

NaCNO (c). Lemoult¹ measured the heat of solution of NaCNO (c) in HCl (aq.) and in HNO_3 (aq.).

NaCNO (aq.). Lemoult¹ measured the heat of solution of NaCNO (c) in water.

NaCN_2H (aq.). Lemoult¹ measured the heat of neutralization of HCN_2H (c), and of HCN_2H (aq.), with NaOH (aq.).

NaCNS (aq.). Joannis¹ measured the heat of neutralization, his data yielding $N=14.04$. The heat of dilution was measured by Partington and Soper¹ in the range 3.55 to 330 H_2O . We have extrapolated the values to infinite dilution.

NaCNS (c). The data of Vrzhesnevskii¹ and Partington and Soper¹ yield, respectively, for S_{200} , -1.77 and -1.80 .

NaCNS(C₂H₅OH). Partington and Soper¹ measured the heat of solution of NaCNS (c) in various amounts of ethyl alcohol.

Na₂SiO₃ (c). The data of Tammann³ (quoted by Mulert¹), who measured the heat of solution in 20% HF (aq.), yield $Q_f = 371.2$. Matignon¹¹ measured the heat of mixing Na₂SiO₃ (c) with HCl (aq.), his data yielding $Q_f = 351$.

Na₂SiO₃ (gls.). In a bomb calorimeter, Mixer⁵ measured the heat of reaction of Si (c) with 2 Na₂O₂ (c) and of SiC (c) with 4 Na₂O₂ (c); Tschernobaeff¹ that of SiO₂ (α Quartz) with Na₂CO₃ (c). Their data yield, respectively, $Q_f = 373.5$, 374.7 , and 348 .

Na₂SiF₆ (aq.). Thomsen¹⁵ and Hantke¹ measured the heat of neutralization of H₂SiF₆ (aq.) with 2 NaOH (aq.).

NaHSiF₆ (aq.). Thomsen¹⁵ measured the heat of mixing H₂SiF₆ (200) with NaOH (200).

Na₂SiF₆ (c). The data of Hantke¹ yield $S = -10.3$. Truchot² measured the heat of reaction of SiF₄ (g) with 2 NaF (110).

Na_nSn_m (c). Biltz and Holverscheit¹ measured the heats of solution, in HCl(8) containing FeCl₃ (aq.), of NaSn₂ (c), NaSn (c), Na₄Sn₃ (c), Na₂Sn (c), Na₄Sn (c), and of their respective component parts.

Na₂SnO₃ (c). Mixer⁷ measured the heat of reaction of Sn (c) with 2 Na₂O₂ (c).

Na₄SnO₄ (aq.). Thomsen¹⁵ measured the heat of mixing SnCl₄ (400) with 8 NaOH (100).

Na₂PbO₃ (c). Mixer⁸ measured the heat of reaction of Pb (c) with 2 Na₂O₂ (c) and of PbO₂ (c) with Na₂O (c). His data yield $Q_f = 202.4$ and 203.2 , respectively.

2 NaI · PbI₂ · nH₂O (c). Mosnier¹ measured the heats of solution of the anhydrous salt, the tetrahydrate, and the hexahydrate.

2 Na₂S₂O₃ · PbS₂O₃ (aq.). Fogh¹ measured the heat of mixing PbS₂O₃ (c) with 2 Na₂S₂O₃ (aq.).

2 Na₂S₂O₃ · PbS₂O₃ (c). Fogh¹ measured the heat of solution.

Na₂ZnO₂ (c). Mixer¹¹ measured the heat of reaction of Zn (c) with Na₂O₂ (c).

Na₂Zn(SO₄)₂ · nH₂O (c). Graham³ measured the heats of solution of the anhydrous salt and of the tetrahydrate.

NaCd_n (c). Biltz and Haase¹ measured the heats of solution of Na (c), Cd (c), NaCd₂ (c), and NaCd₅ (c) in HCl(8).

Na₂CdO₂ (c). Mixer¹⁵ measured the heat of reaction of Cd (c) with Na₂O₂ (c).

NaHg_n (liq.). Berthelot⁵⁶ measured the heat of solution of NaHg₂₅ (liq.) in HCl(330); von Wartenberg⁸ measured the heat of solution of Na (c) in 164 Hg (liq.). Their data yield, respectively, NaHg₂₅ (liq.), $Q_f = 19.6$, and NaHg₁₆₄ (liq.), $Q_f = 20.2$. The heat of dilution of NaHg_n (liq.) with Hg (liq.) was measured by Cady¹ and Richards and Conant.¹

NaHg_n(c). Berthelot⁵⁵ measured the heat of solution of NaHg_{1.03}(c) in water, and also (Berthelot⁵⁶) of the solid amalgams, with $n = 1.05, 2.15, 4.05$, and 6.0 , in HCl(330). von Wartenberg⁸ measured the heat of solution of Na₃Hg(c) in Hg(liq.). Biltz and Meyer² measured the heats of solution, in HCl(8), of the solid amalgams, with $n = \frac{1}{3}, \frac{2}{3}, 1, 1\frac{1}{2}, 2$, and 4 .

***n*NaBr · HgBr₂(aq.).** Varet⁶ measured the heats of mixing HgBr₂(4400) with 1, 2, 4, and 8 moles of NaBr(220), respectively.

4 Na₂S · HgS(aq.). Berthelot¹¹⁵ measured the heat of mixing 6 Na₂S(aq.) with HgCl₂(aq.).

***n*NaCN · Hg(CN)₂(aq.).** Varet² measured the heat of mixing Hg(CN)₂(440) with 1 and 2 moles of NaCN(110), respectively.

***n*NaX · Hg(CN)₂(aq.).** Varet² measured the heat of mixing Hg(CN)₂(440) with 1 and 2 moles of NaCl(110), NaBr(110), and NaI(110), respectively.

NaX · Hg(CN)₂ · *n*H₂O(c). Varet² measured the heats of solution of NaCl · Hg(CN)₂ · $1\frac{1}{2}$ H₂O(c), NaBr · Hg(CN)₂ · 2 H₂O(c), and NaI · Hg(CN)₂ · 2 H₂O(c).

Na₂O · CuO₂(c). Mixer¹² measured the heat of reaction of Na₂O₂(c) with CuO(c).

Na₂CO₃ · CuCO₃ · *n*H₂O(c). de Carli¹ measured the heats of solution of the anhydrous salt and the trihydrate in HCl(314).

Na₂O₂ · Ag₂O(c). Mixer¹² measured the heat of reaction of Na₂O₂(c) with Ag₂O(c).

Na₃Ag(S₂O₃)₂(aq.). Fogh¹ measured the heat of mixing AgNO₃(110) with 5 Na₂S₂O₃(220).

***n*NaCN · AgCN(aq.).** Varet⁵ measured the heats of dissolving AgCN(c) in NaCN(550), 2 NaCN(220), 2 NaCN(330), and 2 NaCN(1320), respectively.

Na₂PtCl₄(aq.). Thomsen¹⁵ measured the heat of reaction of Na₂PtCl₆(900) with 2 CuCl(c).

Na₂PtCl₆(aq.). Thomsen¹⁵ measured the heat of neutralization. His data yield $N = 27.02_{1200}$, with $Q_f = 280.0$. Thomsen¹⁵ measured the heat of reaction of Na₂PtCl₆ · 6 H₂O(c) with 2 Co(c) in HCl(aq.); Gire,² that of Na₂PtCl₆(aq.) with 2 Co(c). Their data yield, respectively, $Q_f = 280.6$ and 285.9 . The dissociation pressure data of Gire,¹ together with the heat of solution, yield $Q_f = 278$.

Na₂PtCl₆(c). Thomsen¹⁵ found $S = 8.49_{800}^{17.6}$; Gire,² $S = 7.09_{4200}^{17}$.

Na₂PtCl₆ · *n*H₂O(c). Thomsen¹⁵ measured the heats of solution of the dihydrate and the hexahydrate.

Na₂PtBr₆(aq.). Thomsen¹⁵ measured the heat of reaction of Na₂PtBr₆(aq.) with 2 Co(c).

Na₂PtBr₆ · *n*H₂O(c). Thomsen¹⁵ measured the heats of solution of the anhydrous salt and the hexahydrate.

Na₂PtI₆(aq.). Pigeon¹ measured the heats of reaction of Na₂PtI₆(aq.), and of 2 I₂(c), with 2 Co(c) in NaI(aq.).

Na_2IrCl_6 (aq.). Ogawa¹ gave, for Na_2IrCl_6 (aq.) + NaCl (aq.) + Hg (liq.) = Na_3IrCl_6 (aq.) + HgCl (c), $Q = 2.21$.

Na_3RhCl_6 (aq.). Gire² measured the heat of reaction of Na_3RhCl_6 (aq.) with $1\frac{1}{2}$ Co (c).

Na_3RhCl_6 (c). Gire² found $S = 7.83_{6000}^{19}$. His data¹ on the dissociation pressure yield $Q_f = 353$.

$\text{Na}_3\text{RhCl}_6 \cdot 12 \text{H}_2\text{O}$ (c). Gire² measured the heat of solution.

Na_2MnO_4 (c). Mixer¹¹ measured the heat of reaction of Mn (c) with 3 Na_2O_2 (c).

2 $\text{NaBr} \cdot \text{MnBr}_2$ (aq.). Varet⁶ measured the heat of mixing MnBr_2 (220) with 2 NaBr (110).

$\text{Na}_2\text{SO}_4 \cdot \text{MnSO}_4 \cdot n\text{H}_2\text{O}$ (c). Graham³ measured the heats of solution of the anhydrous salt and the dihydrate.

$\text{Na}_3\text{FeCO}(\text{CN})_5$ (aq.). Muller⁸ found $N = 41.6$.

$\text{Na}_3\text{FeCO}(\text{CN})_5 \cdot n\text{H}_2\text{O}$ (c). Muller⁸ measured the heats of solution of the anhydrous salt and the heptahydrate.

Na_2CoO_3 (c). Mixer¹¹ measured the heat of reaction of Co (c) with 2 Na_2O_2 (c).

2 $\text{NaBr} \cdot \text{CoBr}_2$ (aq.). Varet⁶ measured the heat of mixing CoBr_2 (220) with 2 NaBr (110).

$\text{Na}_2\text{Ni}(\text{CN})_4$ (aq.). Varet⁶ measured the heat of solution of $\text{Ni}(\text{CN})_2$ (c) in 2 NaCN (aq.).

Na_2CrO_4 (aq.). Thomsen¹⁵ found $N = 24.72_{800}^{18.9}$; Morges,¹ $N = 23.68_{440}^{19.5}$. Their data yield, respectively, Na_2CrO_4 (800), $Q_f = 322.27$, and Na_2CrO_4 (440), $Q_f = 321.4$.

$\text{Na}_2\text{CrO}_4 \cdot n\text{H}_2\text{O}$ (c). Berthelot⁹⁵ measured the heats of solution of the anhydrous salt, the tetrahydrate, and the decahydrate.

Na_2CrO_4 (10). The data of Berthelot⁵¹ yield, for $\text{Na}_2\text{CrO}_4 \cdot 10 \text{H}_2\text{O}$ (c), $F = -12.3$; those of Morgan and Benson,¹ $F = -15.2^{19.9}$. We have selected $F = -15.0$, which yields the value of Q_f for Na_2CrO_4 (10).

$\text{Na}_2\text{Cr}_2\text{O}_7$ (aq.). Thomsen¹⁵ and Morges¹ measured the heat of mixing CrO_3 (aq.) with NaOH (aq.). Their data yield, respectively, $\text{Na}_2\text{Cr}_2\text{O}_7$ (1200), $Q_f = 465.62$, and $\text{Na}_2\text{Cr}_2\text{O}_7$ (660), $Q_f = 465.54$.

Na_2MoO_4 (aq.). Pechard¹ and Pissarjewsky² measured the heat of neutralization of H_2MoO_4 (c) with NaOH (aq.), the latter using an excess of NaOH (aq.). Their data yield, respectively, Na_2MoO_4 (880), $Q_f = 358.6$, and Na_2MoO_4 (440), $Q_f = 355.64$. Pechard¹ performed a "double decomposition" experiment involving Na^+ , MoO_4^- , H^+ , SO_4^- , his data yielding, for Na_2MoO_4 (440), $Q_f = 358.4$.

Na_2MoO_4 (c, II). Mixer¹⁰ measured the heat of reaction of Mo (c) with 3 Na_2O_2 (c).

Na_2MoO_4 (c, I). Hare¹ measured the heat of transition.

Na_2WO_4 (aq.). Pissarjewsky² measured the heat of neutralization of H_2WO_4 (c) with excess NaOH (aq.).

Na_2WO_4 (c, II). Mixer⁶ measured the heat of reaction of W (c) with 3 Na_2O_2 (c).

Na_2WO_4 (c, I). Hare¹ measured the heat of transition.

NaVO_5 (aq.). Ruff and Friedrich¹ measured the heat of solution of V_2O_5 (c) in $(22\frac{3}{4} \text{ NaOH} + 8 \text{ H}_2\text{O}_2)$ (177).

$(\text{Na}_2\text{O}_2)_2 \cdot \text{UO}_4 \cdot 9 \text{ H}_2\text{O}$ (c). Pissarjewsky² measured the heat of solution of this hydrate in $5 \text{ H}_2\text{SO}_4$ (55), and the heat of mixing $(\text{UO}_2\text{SO}_4 + \text{H}_2\text{SO}_4)$ (aq.) with $2 \text{ Na}_2\text{SO}_4$ (310).

$(\text{Na}_2\text{O}_2)_2 \cdot \text{UO}_4$ (c). Pissarjewsky² measured the heat of solution of $(\text{Na}_2\text{O}_2)_2 \cdot \text{UO}_4 \cdot 9 \text{ H}_2\text{O}$ (c) in water.

$\text{Na}_2\text{U}_2\text{O}_7 \cdot 1\frac{1}{2} \text{ H}_2\text{O}$ (c). Pissarjewsky² measured the heat of solution of this hydrate in $4 \text{ H}_2\text{SO}_4$ (55).

NaVO_3 (aq.). Matignon¹² measured the heat of reaction of V_2O_5 (c) with 2 NaOH (aq.) to be 38.3 at 15° .

Na_2UO_4 (c). Mixer¹⁴ measured the heats of the reactions, U (c) + $3 \text{ Na}_2\text{O}_2$ (c) = Na_2UO_4 (c) + $2 \text{ Na}_2\text{O}$ (c), UO_3 (c) + Na_2O (c) = Na_2UO_4 (c), UO_2 (c) + Na_2O_2 (c) = Na_2UO_4 (c), and U_3O_8 (c) + Na_2O_2 (c) + $2 \text{ Na}_2\text{O}$ (c) = $3 \text{ Na}_2\text{UO}_4$ (c), to be 341.8, 96.1, 110.9, and 285.1, respectively; whence, for Na_2UO_4 (c), $Q_f = 500.4, 487.2, 486.7$, and 482.8 .

$n\text{NaCl} \cdot \text{ThCl}_4 \cdot m\text{H}_2\text{O}$ (c). Chauvenet² measured the heats of solution of $2 \text{ NaCl} \cdot \text{ThCl}_4$ (c) and $\text{NaCl} \cdot \text{ThCl}_4 \cdot 10 \text{ H}_2\text{O}$ (c).

NaBO_2 (aq.). Berthelot⁴ measured the heat of mixing H_3BO_3 (220) with NaOH (110); later, Berthelot¹³ performed a "double decomposition" experiment with Na^+ , BO_2^- , H^+ , Cl^- ; and again (Berthelot⁵⁰) measured the heat of mixing H_3BO_3 (220) with NaOH (110). His data yield, respectively, for NaBO_2 (330), $Q_f = 233.1, 233.4$, and 231.7 . Thomsen¹⁵ measured the heat of mixing H_3BO_3 (150) with NaOH (150) and performed a "double decomposition" experiment involving Na^+ , BO_2^- , H^+ , SO_4^- . His data yield, respectively, NaBO_2 (300), $Q_f = 231.6$, and NaBO_2 (150), $Q_f = 232.1$.

$\text{Na}_2\text{B}_4\text{O}_7$ (aq.). Berthelot⁴ and Thomsen¹⁵ measured the heat of mixing $4 \text{ H}_3\text{BO}_3$ (aq.) with 2 NaOH (aq.). Their data yield, respectively, $\text{Na}_2\text{B}_4\text{O}_7$ (1100), $Q_f = 753.5$, and $\text{Na}_2\text{B}_4\text{O}_7$ (900), $Q_f = 752.6$.

$\text{Na}_2\text{B}_4\text{O}_7$ (c). Favre and Valson² measured the heat of solution.

$\text{Na}_2\text{B}_4\text{O}_7 \cdot 10 \text{ H}_2\text{O}$ (c). The data of Thomsen¹⁵ yield $S = -25.8_{1800}$; those of Favre and Valson² $S = -22.2$.

Na_3BO_3 (aq.). Thomsen¹⁵ found $N = 10.32_{600}^{18.3}$.

Na_3BO_3 (c). Mixer⁶ measured the heat of reaction of B_2O_3 (c) with $3 \text{ Na}_2\text{O}$ (c).

$\text{NaBO}_3 \cdot 4 \text{ H}_2\text{O}$ (c). Tanatar⁹ found $S = -11.56$ in water and $S = -8.98$ in H_2SO_4 (200).

NaAlO_2 (c). Mixer¹⁶ measured the heat of reaction of Al_2O_3 (c) with Na_2O (c).

$3 \text{ NaF} \cdot \text{AlF}_3$ (aq.). The data of Baud¹ yield the heat of mixing AlF_3 (aq.) with 3 NaF (aq.).

$3 \text{ NaF} \cdot \text{AlF}_3 \cdot 3\frac{1}{2} \text{ H}_2\text{O}$ (c). Baud¹ measured the heat of mixing AlF_3 (660) with 3 NaF (220) to form $3 \text{ NaF} \cdot \text{AlF}_3 \cdot 3\frac{1}{2} \text{ H}_2\text{O}$ (c).

$3 \text{ NaF} \cdot \text{AlF}_3$ (c, II). Baud¹ measured the heats of solution of $3 \text{ NaF} \cdot \text{AlF}_3$ (c) and of $3 \text{ NaF} \cdot \text{AlF}_3 \cdot 3\frac{1}{2} \text{ H}_2\text{O}$ (c) in HF (aq.).

$3 \text{ NaF} \cdot \text{AlF}_3$ (c, I). Roth and Bertram¹ measured the heat of transition.

$3 \text{ NaF} \cdot \text{AlF}_3$ (liq.). Roth and Bertram¹ measured the heat of fusion.

$n\text{NaCl} \cdot \text{AlCl}_3$ (c). Baud¹ measured the heats of solution of $\text{NaCl} \cdot \text{AlCl}_3$ (c), $3 \text{ NaCl} \cdot \text{AlCl}_3$ (c), and $3 \text{ NaCl} \cdot 2 \text{ AlCl}_3$ (c).

$\text{NaAl}(\text{SO}_4)_2 \cdot 12 \text{ H}_2\text{O}$ (c). Ephraim and Wagner¹ measured the vapor pressure at various temperatures.

$\text{NaCl} \cdot \text{AlCl}_3 \cdot 6\text{NH}_3$ (c). Baud¹ measured the heat of solution.

$\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot n\text{SiO}_2$ (c). Mulert¹ measured the heats of solution of $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 3 \text{ SiO}_2$ (c, natrolite) and of $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4 \text{ SiO}_2$ (c, dehydrated analcite) in 20% HF (aq.).

$n\text{Na}_2\text{SO}_4 \cdot \text{CaSO}_4 \cdot m\text{H}_2\text{O}$ (c). Barre¹ measured the heats of solution of $\text{CaSO}_4 \cdot \text{Na}_2\text{SO}_4$ (c), $\text{CaSO}_4 \cdot 2 \text{ H}_2\text{O}$ (c) + Na_2SO_4 (c), $2 \text{ Na}_2\text{SO}_4 \cdot \text{CaSO}_4 \cdot 2 \text{ H}_2\text{O}$ (c), and $2 \text{ Na}_2\text{SO}_4$ (c) + $\text{CaSO}_4 \cdot 2 \text{ H}_2\text{O}$ (c).

$\text{NaSrPO}_4 \cdot 9 \text{ H}_2\text{O}$ (c). Joly⁴ measured the heat of reaction of Na_3PO_4 (aq.) with SrCl_2 (aq.).

$\text{NaSrAsO}_4 \cdot 9 \cdot \text{H}_2\text{O}$ (c). Joly⁴ measured the heat of reaction of Na_3AsO_4 (aq.) with SrCl_2 (aq.).

$\text{NaBaPO}_4 \cdot 9 \text{ H}_2\text{O}$ (c). Joly⁴ measured the heat of reaction of Na_3PO_4 (aq.) with BaCl_2 (aq.).

$\text{NaBaAsO}_4 \cdot 9 \text{ H}_2\text{O}$ (c). Joly⁴ measured the heat of reaction of Na_3AsO_4 (aq.) with BaCl_2 (aq.).

NaLiClI(c, melt) . Beketoff⁸ measured the heats of solution of the melt, of LiCl (c) + NaI (c), and of LiI (c) + NaCl (c).

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K (c). Standard state.

K (liq.). The data on the heat of fusion yield the following values: Joannis,² -0.61 ; Rengade,⁴ -0.574 ; Bridgman,² -0.501 .

K (g). The vapor pressure of potassium was measured by Kroner,¹ Fiock and Rodebush,¹ Edmondson and Egerton,^{1, 2} and Killian.¹ See also van Laar⁹ and Rodebush.² Following the same procedure as with sodium, we have calculated that the amount of K_2 in potassium vapor at these temperatures is less than 1%. For the heat of vaporization of K (liq.), we have selected $V = -20.00 + 0.0025(t + 273.1)$; whence, for K (g), $Q_f = -19.80$.

The values for the energy states of gaseous monatomic potassium are from Fowler,³ de Bruin,^{1, 4} and Bowen.^{1, 5} See also Braunbek¹ and Bacher and Goudsmit.¹

K₂ (g). Nusbaum and Loomis¹ and Loomis and Nusbaum² reported the energy of dissociation, K_2 (g) = 2 K (g), with each substance in its normal state, to be 0.51 ± 0.02 volt-electrons. See also Carelli and Pringsheim,¹ Crane and Christy,¹ and Ditchburn.¹ The values for the

energy states of gaseous diatomic potassium are from Mulliken.⁶ See also Jevons.¹

KOH (aq.). The heat of solution of K (c) in water was measured by Favre and Silbermann,³ Thomsen,¹⁵ Joannis,² and Rengade.¹ The data of the last three investigations yield for the reaction, $K(c) + H_2O(liq.) = KOH(200) + \frac{1}{2}H_2(g)$, the respective values, $Q = 48.1 \pm 0.3$, 45.83 ± 0.28 , and 46.42 ± 0.15 . We have selected 46.4, whence for $KOH(200)$, $Q_f = 114.8$. The heat of dilution of $KOH(aq.)$ was measured by Berthelot,²⁰ Sabatier,¹ Thomsen,¹⁵ de Forcrand,⁵⁵ Pratt,¹ and Richards and Rowe.² The data in the range from 25 to 400 H_2O were reviewed by Rossini,⁵ who gave values from ∞ to 25 H_2O . The other data have been utilized to obtain values from 25 to 3 H_2O .

$K^+(\infty)$. From the foregoing data we have computed, for $K^+(\infty) + OH^-(\infty)$, $Q_f = 114.930$; whence, for $K^+(\infty)$, $Q_f = 60.27$.

KOH (c, II). The heat of solution data yield the following values for S_{200} : Berthelot,¹⁰ 12.76; Thomsen,¹⁵ 13.18; and de Forcrand,³⁴ 12.80.

$KOH \cdot nH_2O(c)$. Berthelot²⁰ measured the heats of solution of the hydrates with $\frac{7}{2}$ and 2 moles of H_2O ; de Forcrand,³⁴ those with 0.25, 0.535, 0.91, 1.16, and 1.55 moles of H_2O .

KOH (c, I). Hevesy¹ determined the heat of transition.

KOH (g). von Wartenberg and Albrecht¹ gave $V = -32.45^{1500}$.

$K_2O(c)$. Rengade³ measured the heats of solution of K (c) and $K_2O(c)$. The difference gives, for $K_2O(c) + H_2(g) = 2K(c) + H_2O(liq.)$, $Q = -17.8$; whence, for $K_2O(c)$, $Q_f = 86.2$. Beketoff's² data on the heat of solution of $K_2O(c)$, yield $Q_f = 94(?)$.

$K_2O_n(c)$. de Forcrand⁶⁶ measured the heats of solution of $K_2O_3(c)$ and $K_2O_4(c)$ in $H_2SO_4(aq.)$.

KH (c). Moutier¹ calculated the heat of dissociation from the dissociation pressure data of Troost and Hautefeuille.⁸ Keyes¹ computed D from his data on the dissociation pressure. Kasarnowsky and Proskurnin¹ reported that Monossohn measured the heats of solution of K (c) and KH (c), and found, for the latter, $Q_f = 8$ to 10. The data of Moutier and Keyes yield, respectively, for KH (c), $Q_f = 14.7$ and 9.8.

KF (aq.). Guntz¹ and Mulert¹ measured the heat of neutralization of HF (aq.) with KOH (aq.). Their data yield, respectively, $KF(400)$, $Q_f = 138.12$, and $KF(80)$, $Q_f = 140.7$. Berthelot and Guntz² measured the heat of mixing $HCl(110)$ with $KF(110)$ and of $HF(110)$ with $KCl(110)$; whence, for $KF(110)$, $Q_f = 138.70$. The heat of dilution was measured by Lange and Eichler,¹ Lange and Messner,² de Forcrand,⁵⁸ and Guntz.¹

KF (c). The heat of solution data yield the following values for S_{200} : Guntz,¹ 3.60; de Forcrand,^{12, 58} 4.20; and Lange and Eichler,¹ 3.85.

KF (liq.). According to Plato,² the heat of fusion is -6.27^{880}

KF (g). The vapor pressure was measured by Ruff, Schmidt, and Mugdan¹ and von Wartenberg and Schultz.¹ See also van Laar.⁹

$KF \cdot 2H_2O(c)$. The data on the heat of solution yield the following

values for S_{200} : Guntz¹, -1.05 ; de Forcrand,⁵⁸ -2.11 ; and Lange and Eichler,¹ -1.96 .

KF · 4 H₂O (c). de Forcrand⁵⁸ measured the heat of solution.

KHF₂ (aq.). Guntz¹ measured the heat of mixing KOH (aq.) with 2 HF (aq.) and of HF (aq.) with KF (aq.), his data yielding, respectively, KHF₂ (aq.), $Q_f = 213.38$, and KHF₂(400), $Q_f = 213.53$. Guntz¹ also measured the heat of dilution of KHF₂ (aq.) from 28 to 222 H₂O. We have extrapolated his data to infinite dilution, assuming no dissociation of HF₂⁻ (aq.).

KHF₂ (c). The data of Guntz¹ and de Forcrand⁶⁰ yield identical values for the heat of solution.

KF · nHF (c). Guntz⁴ measured the heats of solution of KF · 2 HF (c) and KF · 3 HF (c).

KCl (aq.). The heat of neutralization of HCl (aq.) with KOH (aq.) was measured by Hess,^{1, 5} Andrews,^{2, 7, 11} Favre and Silbermann,³ Favre,³ Berthelot,^{10, 19, 4, 84} Thomsen,¹⁵ Muller,^{1, 10} Richards and Rowe,³ and Gillespie, Lambert, and Gibson.¹ The data from the last two investigations were recomputed by Rossini,⁶ giving $N = 14.085_{201}$. The heat of dilution of KCl (aq.) was measured by van Deventer and van der Stadt,¹ Scholz,³ Stackelberg,¹ Varali-Thevenet,¹ Rümelin,¹ Bishop,¹ Brönsted,⁹ Magie,¹ Colson,⁵ Pratt,¹ Stearns and Smith,¹ Richards and Rowe,² Laksonen,¹ Mondain-Monval,³ Wust and Lange,¹ Sandonnini and Gerosa,¹ Nernst and Orthmann,^{1, 2} Harrison and Perman,¹ Nernst and Naudé,¹ Holluta and Werner,¹ Lange and Leighton,¹ and Partington and Soper.¹ The modern data on the dilute range were reviewed by Rossini,⁵ who gave values from ∞ to 25 H₂O.

KCl (c). The data on the heat of solution of KCl (c) have been recomputed to give the following values for S_{200} (the value following the investigator's name shows the data before conversion to 18° and 200 H₂O): Andrews,¹⁴ $-\dots$; Winkelmann,¹ -5.02_{132}^0 , -4.37 ; Berthelot,¹⁰ -4.19_{200}^{21} , -4.31 ; Rechenberg,¹ $-4.43_{200}^{18.2}$, -4.44 ; Ostwald,¹ -4.56_{278}^{17} , -4.50 ; Berthelot and Ilosvay,¹ -4.30_{104}^{18} , -4.36 ; Thomsen,¹⁵ -4.427_{200}^{18} , -4.427 ; Pickering,⁷ -4.480_{400}^{18} , -4.467 ; Scholz,¹ -5.28_{220}^0 , -4.48 ; Stackelberg,¹ -4.291_{100}^{18} , -4.362 ; Varali-Thevenet,¹ -5.52_{415}^0 , -4.79 ; Zemczuzny and Rambach,¹ $-4.433_{100}^{18?}$, $-4.45(?)$; Brönsted,⁹ $-4.404_{200}^{19.7}$, -4.466 ; Haigh,¹ -4.321_{400}^{20-22} , -4.44 ; Colson,⁵ $-4.545_{220}^{17.9}$, -4.542 ; Cohen, Helder mann, and Moesveld,¹ -4.398_{200}^{18} , -4.398 ; Laksonen,² -5.28_{220}^0 , -4.57 ; Mondain-Monval,³ $-4.27_{100-200}^{18}$, -4.30 ; Wust and Lange,¹ -4.123_{50}^{25} , -4.500 ; Gire,¹ $-4.66_{250}^{11.5}$, -4.41 ; Sandonnini and Gerosa,¹ $-4.508_{214}^{18?}$, $-4.51(?)$; Holluta and Werner,¹ $-4.517_{90.3}^{18.5}$, -4.59 ; Cohen and Kooy,¹ -4.373_{200}^{20} , -4.447 ; Partington and Soper,¹ -4.266_{180}^{25} , -4.518 ; Roth and Eymann,¹ -4.322_{150}^{21} , -4.448 ; Lange and Monheim,² $-4.694_{500}^{12.5}$, -4.453 ; Agostini,¹ $-4.314_{300}^?$ and $-4.32_{800}^?$, $(?)$. We have selected as the best value for S_{200} , the average of those from the data of Cohen and Kooy, -4.447 , Roth and Eymann, -4.448 , and Lange and Monheim, -4.453 .

There is an old value by Andrews¹⁶ for the heat of the reaction $\text{K (c)} + \frac{1}{2} \text{Cl}_2 \text{ (g)} = \text{KCl (c)}$.

KCl (liq.). The data on the heat of fusion are: Zemczuzny and Rambach,¹ -4.69 ; Plato,¹ -6.41 .

KCl (g). The vapor pressure was measured by Hackspill and Grandadam,¹ Fiock and Rodebush,¹ Horiba and Baba,¹ Jackson and Morgan,¹ Ruff and Mugdan,¹ and von Wartenberg and Albrecht.¹ We have taken $V = -38.4^{1200}$. From the spectral absorption limit, Franck, Kuhn, and Rollefson¹ calculated, for KCl (g) , $D^\circ = -103$.

KClO (aq.). Berthelot¹⁵¹ measured the heat of reaction of KOH (aq.) with HClO (aq.) , and also (Berthelot²⁶) of 2KOH (aq.) with $\text{Cl}_2 \text{ (aq.)}$. Neumann and Muller² performed similar experiments. Their data yield the following values, respectively, for KClO (aq.) , 85.81 , 86.74 , 86.36 , and 85.44 .

KClO₃ (aq.). From the ions, we have computed, for $\text{KClO}_3(\infty)$, $Qf = 81.02$. The data of Stackelberg¹ give the heat of dilution from 125 to $500 \text{ H}_2\text{O}$. We have estimated the values to $\infty \text{ H}_2\text{O}$.

KClO₃ (c). The data on the heat of solution yield the following values for S_{400} : Berthelot,¹⁰ -9.36 ; Thomsen,¹⁵ -10.18 ; Stackelberg,¹ -10.15 . Frankland¹ measured, in a bomb calorimeter, the heat of decomposition of $\text{KClO}_3 \text{ (c)}$ into KCl (c) and $\text{O}_2 \text{ (g)}$. Thomsen¹⁵ also determined the heat of decomposition of $\text{KClO}_3 \text{ (c)}$, his data yielding $Qf = 94.65$.

KClO₄ (c). Berthelot and Vielle⁴ determined the heat of decomposition of $\text{KClO}_4 \text{ (c)}$ into KCl (c) and $\text{O}_2 \text{ (g)}$, in a bomb calorimeter using potassium picrate and ammonium picrate as the auxiliary combustibles. Their data yield, for $\text{KClO}_4 \text{ (c)}$, $Qf = 110.9$ and 113.0 , respectively.

KClO₄ (aq.). The heat of solution data have been recomputed to give the following values for S : Berthelot,⁷⁹ -11.54_{300} ; Stackelberg,¹ -12.30_{1000} , and -11.81_{500} ; Noyes and Samet,¹ -12.27_{460} ; and Latimer and Ahlberg,¹ -12.62_{1800} . We have estimated the heat of dilution from 200 to $\infty \text{ H}_2\text{O}$, utilizing the data on the heat of solution, which were obtained at various concentrations.

KBr (aq.). The heat of neutralization of HBr (aq.) with KOH (aq.) was measured by Berthelot,¹⁹ Thomsen,¹⁵ and Richards and Rowe.³ The data of Richards and Rowe have been recomputed, giving $N = 14.061_{201}$. Data on the heat of dilution were reported by Wust and Lange,² Rümelin,¹ Dunnington and Hoggard,¹ and Berthelot.⁸³

KBr (c). The data on the heat of solution have been recomputed, giving the following values for S_{200} : Berthelot,¹⁰ -5.15 ; Berthelot and Ilosvay,¹ -5.01 ; Thomsen,¹⁵ -5.091 ; Scholz,¹ -5.07 ; Brönsted,⁴ -5.110 ; Walden,³ -5.085 ; and Wust and Lange,² -5.119 .

KBr (liq.). The value for the heat of fusion has been estimated.

KBr (g). The vapor pressure of KBr was measured by Fiock and Rodebush,¹ von Wartenberg and Albrecht,¹ and Ruff and Mugdan.¹ We have taken Fiock and Rodebush's value, $V = -40.1^{1000}$. See also Sommer-meyer¹ and Franck, Kuhn, and Rollefson.¹

KBrO (aq.). Thomsen¹⁵ measured the heat of reaction between Br_2 (1400) and 2 KOH (40). His data yield, for KBrO (aq.), $Q_f = 81.70$. Berthelot's⁸¹ data on the reaction between bromine and aqueous KOH are apparently uncertain.

KBrO₃ (aq.). Thomsen found $N = 13.77_{801}$. The heat of dilution from 200 to ∞ H_2O has been estimated.

KBrO₃ (c). The heat of solution data yield the following values for S_{400} : Berthelot,⁴⁵ -9.32 ; Thomsen,¹⁵ -10.12 ; and Stackelberg,¹ -9.87 .

KI (aq.). The heat of neutralization of HI (aq.) with KOH (aq.) was measured by Berthelot,¹⁹ Thomsen,¹⁵ and Richards and Rowe.³ The data of Richards and Rowe have been recomputed, giving $N = 13.975_{201}$. The heat of dilution was measured by Wust and Lange² and Dunnington and Hoggard.¹

KI (c). The data on the heat of solution yield the following values for S_{200} : Berthelot,¹⁰ -5.00 ; Berthelot and Ilosvay,¹ -4.99 ; Thomsen,¹⁵ -5.197 ; Scholz,¹ -5.05 ; Walden,³ -5.206 ; and Wust and Lange,² -5.168 . We have selected as the best value the average of those of Thomsen, Walden, and Wust and Lange.

KI (g). Vapor pressure data were reported by Fiock and Rodebush,¹ Ruff and Mugdan,¹ and von Wartenberg and Albrecht.¹ See also Mayer,³ Weinberg,² and Reis.¹ We have selected $V = -37.6^{900}$. From Franck, Kuhn, and Rollefson's¹ value for $\text{KI (g)} = \text{K (g)} + \text{I (g)}$, calculated from the spectral absorption limit, we have computed, for KI (g) , $Q_f = 30.3$; while from Mayer's³ value for $\text{KI (g)} = \text{K}^+ \text{(g)} + \text{I}^- \text{(g)}$, we have computed, for KI (g) , $Q_f = 28.2$. See also Sommermeyer.¹

KI (methyl alcohol, ethyl alcohol, acetonitrile, acetone). Walden³ measured the heat of solution of KI (c) in these liquids.

KI₃ (c). Berthelot⁶⁴ measured the heat of solution of KI_3 (c) and of KI (c) in H_2O , and of I_2 (c) in KI (aq.).

KIO₃ (aq.). Berthelot⁴² and Thomsen¹⁵ measured the heat of neutralization of HIO_3 (aq.) with KOH (aq.). Their data yield, respectively, $N = 14.10_{440}$ and 13.80_{300} , giving, for $\text{KIO}_3(800)$, $Q_f = 115.00$ and 114.85 . From Berthelot's⁴⁵ measurement of the heat of reaction of 3 I_2 (c) with 6 KOH (220), we have calculated, for KIO_3 (aq.), $Q_f = 114.5$. Some few data on the heat of dilution of KIO_3 (aq.), from 110 to 500 H_2O , were reported by Berthelot⁴⁵ and Stackelberg.¹ We have estimated the values to 100 H_2O and to infinite dilution.

KIO₃ (c). The data on the heat of solution yield the following values for S_{400} : Berthelot,⁴⁵ -5.57 ; Thomsen,¹⁵ -6.78 ; and Stackelberg,¹ -6.61 .

KIO₄ (aq.). The data of Thomsen¹⁵ yield $N = 5.13_{1200}$.

KH_4IO_6 , $\text{K}_2\text{H}_5\text{IO}_6$, $\text{K}_3\text{H}_2\text{IO}_6$ (aq.). Thomsen¹⁵ measured the heat of mixing H_5IO_6 (600) with 1, 2, and 3 moles of KOH (600), respectively.

$\text{KIO}_3 \cdot \text{HIO}_3$ (aq.). Thomsen¹⁵ measured the heat of mixing KIO_3 (800) with HIO_3 (800).

$\text{KIO}_3 \cdot \text{HIO}_3$ (c). Berthelot⁴⁵ measured the heat of solution.

KI · KCl (c, fresh melt). Beketoff⁸ measured the heats of solution of the fresh melt and of KCl (c) + KI (c).

K₂S (aq.). Sabatier¹ measured the heat of neutralization of 2 KOH (200) with H₂S (g). His data yield, for K₂S(400), $Q_f = 110.4$. Sabatier¹ measured the heat of dilution from 7 to 400 H₂O. We have estimated the heat of dilution from 400 to ∞ H₂O to be zero.

K₂S (c). Sabatier¹ found $S = 10_{580}$, Favre and Silbermann,³ $S = 10.6$, Rengade and Costeanu,¹ $S = 22.6_{400}$?

K₂S · nH₂O (c). Sabatier¹ measured the heats of solution of the dihydrate and the pentahydrate.

K₂S_n (aq.). Sabatier¹ measured the heats of reaction of I₂ (c) with K₂S₃₃ (aq.), and K₂S₄ (aq.), respectively.

K₂S₃₃ (c). Sabatier¹ measured the heat of solution.

K₂S₄ · nH₂O (c). Sabatier¹ measured the heats of solution of the anhydrous salt, the hemihydrate, and the dihydrate.

KHS (aq.). Sabatier¹ measured the heat of reaction of H₂S (aq.) with KOH (aq.), and of KHS (aq.) with KOH (aq.). His data yield, for KHS(200), $Q_f = 64.07$ and 64.47 , respectively. The heat of dilution was measured by Sabatier¹ from 2.8 to 200 H₂O. We have estimated the value to ∞ H₂O, assuming no dissociation of HS⁻ (aq.).

KHS · nH₂O (c). Sabatier¹ measured the heats of solution of KHS (c) and KHS · $\frac{1}{4}$ H₂O (c).

K₂SO₄ (aq.). Berthelot^{4, 7} and Thomsen¹⁵ each measured the heat of neutralization of H₂SO₄ (aq.) with KOH (aq.), and performed a number of pairs of "double decomposition" experiments involving K₂SO₄ (aq.). Muller¹⁰ measured the heat of neutralization of H₂SO₄(55) with KOH (aq.) of various concentrations. Brönsted,¹⁰ from electromotive force measurements, obtained the heat of the reaction, KCl (c) + $\frac{1}{2}$ Na₂SO₄ (c) = NaCl (c) + $\frac{1}{2}$ K₂SO₄ (c), whence, by using the heat of solution of K₂SO₄ (c), we have obtained a value for K₂SO₄ (aq.). The foregoing data have been recomputed to give the following values for K₂SO₄(400): Berthelot, neutralization, 336.46; Berthelot, "double decomposition," K⁺, SO₄⁻, Na⁺, OH⁻, 336.25; Berthelot, "double decomposition," K⁺, SO₄⁻, H⁺, Cl⁻, 337.05; Berthelot, "double decomposition," K⁺, SO₄⁻, H⁺, NO₃⁻, 336.01; Berthelot, "double decomposition," K⁺, SO₄⁻, Na⁺, Cl⁻, 336.37; Berthelot, "double decomposition," K⁺, SO₄⁻, Na⁺, NO₃⁻, 335.91; Thomsen, neutralization, 336.05; Thomsen, "double decomposition," K⁺, SO₄⁻, H⁺, NO₃⁻, 336.69; Thomsen, "double decomposition," K⁺, SO₄⁻, Na⁺, OH⁻, 336.12; Thomsen, "double decomposition," K⁺, SO₄⁻, H⁺, Cl⁻, 336.56; Thomsen, "double decomposition," K⁺, SO₄⁻, H⁺, Cl⁻, 336.33; Muller, neutralization, 336.58; Brönsted, Q_f of solid + heat of solution, 336.44. There are old values of the heat of neutralization by Hess,⁵ Andrews,^{7, 2} Favre and Silbermann,³ and Favre.³ The heat of dilution of K₂SO₄ (aq.) was measured by Lange and Streeck,¹ Mondain-Monval,³ Brönsted,⁹ Rümelin,¹ Varali-Thevenet,¹ and Scholz.¹

K₂SO₄ (c, II). The data on the heat of solution yield the following values for S_{400} : Favre and Silbermann,³ (?); Favre,⁸ (?); Berthelot,¹⁰ (?); Berthelot and Ilosvay,¹ (?); Tilden,² -6.13; Pickering,² -6.54; Thomsen,¹⁵ -6.33; Scholz,¹ -6.72; Varali-Thevenet,¹ -6.76; Brönsted,⁹ -6.38; Mondain-Monval,³ -6.60 (?); Cohen and Kooy,¹ -6.444. We have taken the average of the values from Pickering, Thomsen, Brönsted, and Cohen and Kooy.

KHSO₄ (aq.). Berthelot⁶ and Thomsen¹⁵ measured the heat of mixing H₂SO₄ (aq.) with K₂SO₄ (aq.). Their data yield, for KHSO₄(200), $Qf = 273.02$ and 273.20 , respectively. The heat of dilution of KHSO₄ (aq.) was measured by Berthelot⁶ and Thomsen.¹⁵

KHSO₄ (c, III). The data on the heat of solution yield the following values for S_{200} : Graham,² (?); Favre,⁸ (?); Berthelot,¹⁰ -3.0 (?); Thomsen,¹⁵ -3.75.

KHSO₄ (c, II), KHSO₄ (c, I). Bridgman⁷ determined the heats of transition.

KHSO₃ (aq.). Berthelot⁹² measured the heat of mixing H₂SO₃(275) with KOH(110). His data yield, for KHSO₃(385), $Qf = 209.70$.

K₂SO₄ (c, I). Hare¹ measured the heat of transition.

K₂SO₃ (aq.). Berthelot⁹² measured the heat of neutralization of H₂SO₃ (aq.) with KOH (aq.). His data yield, for K₂SO₃(500), $Qf = 271.2$.

K₂SO₃ (c). Berthelot⁹² measured the heat of solution. The data of Martin and Metz,¹ who measured the heat of reaction, in a bomb calorimeter, between K₂SO₃ (c), Mg (c), and O₂ (g), yield $Qf = 273$.

K₂SO₃ · H₂O (c). Berthelot⁹² measured the heat of solution.

K₂S₂O₅ · nH₂O (c). Berthelot⁹⁴ measured the heats of solution of the anhydrous salt and the hemihydrate.

K₂S₂O₃ (c). Berthelot⁹³ measured the heat of solution. The data of Martin and Metz,¹ who measured, in a bomb calorimeter, the heat of the reaction, K₂S₂O₃ (c) + Mg (c) + 2½ O₂ (g) = K₂SO₄ (c) + MgSO₄ (c), yield $Qf = 283$.

K₂S₂O₆ (c). The data of Martin and Metz¹ (see K₂S₂O₃ (c)) yield $Qf = 415.8$. The data of Thomsen¹⁵ on the reaction, K₂S₂O₆ (c) = K₂SO₄ (c) + SO₂ (g), yield $Qf = 413.7$.

K₂S₂O₆ (aq.). Thomsen¹⁵ measured the heat of solution of K₂S₂O₆ (c).

K₂S₂O₇ (c). Berthelot⁴ measured the heat of solution of K₂S₂O₇ (c) in H₂O to form 2 KHSO₄ (aq.).

K₂S₂O₇ (aq.). Berthelot⁴ measured the heat of solution of K₂S₂O₇ (c) in H₂O, taking the initial heat of solution, i. e., before S₂O₇⁻ (aq.) was hydrated to 2 HSO₄⁻ (aq.).

K₂S₂O₈ (aq.). The value of Qf for this substance is computed from those for the aqueous ions.

K₂S₂O₈ (c). Berthelot¹⁰⁷ measured the heat of solution.

K₂S₃O₆ (c). Berthelot¹⁰³ measured the heat of reaction of K₂S₃O₆ (c) with KBr₃ (aq.). His data yield $Qf = 411.2$. The data of Martin and Metz¹ (see K₂S₂O₃ (c)) yield $Qf = 402$.

$\text{K}_2\text{S}_3\text{O}_6$ (aq.). The data of Berthelot¹⁰³ and Thomsen¹⁵ yield, respectively, $S = -12.45_{650}$ and -12.38_{500} .

$\text{K}_2\text{S}_4\text{O}_6$ (c). The data of Martin and Metz¹ (see $\text{K}_2\text{S}_2\text{O}_3$ (c)) yield $Qf = 393$. Thomsen¹⁵ measured the heat of solution.

$\text{K}_2\text{S}_4\text{O}_6$ (aq.). This value is obtained from those for the aqueous ions.

$\text{K}_2\text{S}_5\text{O}_6$ (aq.). Berthelot¹⁰³ measured the heat of reaction of $\text{K}_2\text{S}_5\text{O}_6$ (aq.) with 10 KBr_3 (aq.), and also of $\text{K}_2\text{S}_5\text{O}_6$ (aq.) with 3 NaOH (aq.). His data yield, respectively, $Qf = 398.1$ and 400.7 .

$\text{K}_2\text{S}_5\text{O}_6$ (c). The data of Martin and Metz¹ (see $\text{K}_2\text{S}_2\text{O}_3$ (c)) yield $Qf = 386$. We have estimated 408.

$\text{K}_2\text{S}_5\text{O}_6 \cdot 1\frac{1}{2} \text{H}_2\text{O}$ (c). Berthelot¹⁰³ measured the heat of solution.

$\text{KI} \cdot 4 \text{SO}_2$ (c). Ephraim and Kornblum¹ found $D = -9.67$.

K_2Se (aq.). Fabre¹ measured the heat of reaction of H_2S (g) with 2 KOH (220), and of H_2S (4000) with 2 KOH (220). His data yield, for K_2Se (440), $Qf = 82.72$, and for K_2Se (4400), $Qf = 83.76$.

$\text{K}_2\text{Se} \cdot n\text{H}_2\text{O}$ (c). Fabre¹ measured the heats of solution of the anhydrous salt and of the hydrates, with 9, 14, and 19 moles of H_2O .

KHSe (aq.). The data of Fabre,¹ who measured the heat of mixing KOH (aq.) with H_2Se (4000), yield, for KHSe (4200), $Qf = 34.03$.

K_2SeO_4 (aq.). The data of Metzner^{2, 1} yield $N = 31.19_{440}$, whence for K_2SeO_4 (440), $Qf = 266.95$. We have estimated the heat of dilution to $\infty \text{H}_2\text{O}$.

KHSeO_4 (aq.). Metzner^{2, 1} found, for the heat of mixing H_2SeO_4 (220) with K_2SeO_4 (220), $Q^{15} = -1.24$.

K_2TeO_3 (aq.). Metzner^{1, 2} found, for the heat of solution of TeO_2 (c) in KOH (aq.), $Q^{15} = 22.76$.

K_2TeO_4 (aq.). The data of Metzner^{1, 2} yield $N = 31.24_{220}$.

KNO_3 (aq.). The heat of neutralization of HNO_3 (aq.) with KOH (aq.) was measured by Hess,⁶ Andrews,^{2, 7, 11} Favre and Silbermann,³ Favre,³ Berthelot,⁴ Thomsen,¹⁵ and Richards and Rowe.³ The data of Richards and Rowe were recomputed by Rossini,⁶ giving $N = 14.165_{201}$. Data on the heat of dilution of KNO_3 (aq.) were given by Winklemann,¹ Scholz,¹ Stackelberg,¹ Varali-Thevenet,¹ Rümelin,¹ Bishop,¹ Colson,⁵ Pratt,¹ Richards and Rowe,² Mondain-Monval,³ Nernst and Orthmann,¹ Nernst and Naudé,¹ Roth,¹¹ Roth and Eymann,¹ Roth and Muller,⁵ and Lange and Monheim.² The modern data in the dilute range were reviewed by Rossini,⁵ who gave values from ∞ to $25 \text{H}_2\text{O}$.

KNO_3 (c, III). The data on the heat of solution have been recomputed to give the following values for S_{200} : Person,⁶ (?); Winkelmann,¹ -8.42 ; Berthelot,¹⁰ (?); Tilden,² -8.12 ; Thomsen,¹⁵ -8.49 ; Pickering,⁷ -8.41 ; Scholz,¹ -8.51 ; Stackelberg,¹ -8.43 ; Varali-Thevenet,¹ -8.28 ; Haigh,¹ -8.28 ; Colson,⁵ -8.65 ; Mondain-Monval,³ -8.3 ; Holluta and Werner,¹ -8.57 ; Berenger-Calvet,¹ -8.25 ; Zawidski and Schogger,¹ (?); Roth,¹¹ -8.282 ; Roth and Muller,⁵ -8.467 ; Cohen and Kooy,¹ -8.395 ; Roth and Eymann,¹ -8.399 ; Lange and Monheim,¹ -8.404 . We have taken the average of the last three values.

KNO₃ (c, II), KNO₃ (c, I). Potassium nitrate shows a change of crystal form at about 128°. According to Bridgeman's^{6a} analysis, there are really two transitions with $T=0.62_{\text{I} \rightarrow \text{II}}^{126}$ and $1.17_{\text{II} \rightarrow \text{III}}^{128}$. See also Bellati and Romanese.³

KNO₃ (liq.). Data for obtaining the heat of fusion were recorded by Person¹ and Goodwin and Kalmus.¹

KNH₃ (c). Joannis³ found $D = -6.4$.

KX · nNH₃ (c). Biltz and Hansen¹ measured the temperature coefficient of the dissociation pressure for KBr · 4NH₃ (c), KI · 4NH₃ (c), and KI · 6NH₃ (c).

KH₂PO₄ (c). Graham¹ measured the heat of solution.

KH₂AsO₄ (c). Graham¹ measured the heat of solution.

K₂CO₃ (aq.). Berthelot⁴ measured the heat of mixing CO₂ (aq.) with 2KOH (aq.); Muller¹ that of mixing K₂CO₃ (aq.) with 2HCl (aq.). Their data yield, respectively, for K₂CO₃ (1800), $Q_f = 280.61$, and for K₂CO₃ (1950), $Q_f = 280.66$. Data on the heat of dilution were given by Berthelot,⁴ Thomsen,¹⁵ Rümelin,¹ and de Forcrand.⁵² We have estimated the values from 400 to ∞ H₂O.

K₂CO₃ (c). The data on the heat of solution yield the following values for S_{400} : Berthelot,¹⁰ 6.8 (?); Berthelot and Illosvay,¹ 6.66; Ostwald,¹ 6.64; Thomsen,¹⁵ 6.59.

K₂CO₃ (liq.). Sackur¹ reported the heat of fusion.

K₂CO₃ · nH₂O (c). Thomsen¹⁵ measured the heats of solution of K₂CO₃ · $\frac{1}{2}$ H₂O (c) and K₂CO₃ · $1\frac{1}{2}$ H₂O (c). Berthelot's¹⁰ measurement of the heat of solution of the latter lacks adequate information as to concentration and temperature.

KHCO₃ (aq.). Berthelot⁴ measured the heat of mixing CO₂ (aq.) with KOH (aq.); Muller¹ that of mixing KHCO₃ (aq.) with HCl (aq.). Their data yield, respectively, for KHCO₃ (1900), $Q_f = 225.01$, and for KHCO₃ (1000), $Q_f = 224.96$.

KHCO₃ (c). The data of Berthelot¹⁰ and de Forcrand⁵³ yield for the heat of solution, -5.2_{400} and -5.2_{220} , respectively. The dissociation pressure data of Caven and Sand² yield $Q_f = 228.9$.

5(K₂CO₃ · $1\frac{1}{2}$ H₂O) · 4KHCO₃ (c). de Forcrand⁵⁴ measured the heat of solution.

K₂C₂O₄ (aq.). Berthelot¹⁰ measured the heat of neutralization of H₂C₂O₄ (220) with 2KOH (110). Berthelot and Guntz¹ measured the heat of mixing KF (110) with $\frac{1}{2}$ H₂C₂O₄ (220), and of HF (110) with $\frac{1}{2}$ K₂C₂O₄ (220). Their data yield, respectively, for K₂C₂O₄ (440), $Q_f = 316.16$, and for K₂C₂O₄ (220), $Q_f = 316.5$.

K₂C₂O₄ (c). Berthelot¹⁰ measured the heat of solution of potassium oxalate.

K₂C₂O₄ · H₂O (c). For the heat of solution, the data of Berthelot¹⁰ and Thomsen¹⁵ yield, respectively, -7.57_{400} and -7.52_{800} .

KCHO₂ (aq.). Berthelot⁸ measured the heat of neutralization of aqueous formic acid with KOH (aq.), and performed "double decom-

position" experiments involving K^+ , CHO_2^- , H^+ , Cl^- . His data yield, respectively, for $KCHO_2$ (480), $Qf=159.67$, and for $KCHO_2$ (330), $Qf=160.18$.

$KCHO_2$ (c). Berthelot¹⁰ measured the heat of solution of potassium formate.

$KC_2H_3O_2$ (aq.). Berthelot¹⁰ and Berthelot and Guntz¹ performed "double decomposition" experiments involving K^+ , $C_2H_3O_2^-$, H^+ , Cl^- and K^+ , $C_2H_3O_2^-$, H^+ , F^- , respectively. Their data yield, for $KC_2H_3O_2$ (110), $Qf=178.43$ and 177.69 . Thomsen¹⁵ measured the heat of dilution of aqueous potassium acetate from 5 to 200 H_2O . We have estimated the values to infinite dilution.

$KC_2H_3O_2$ (c). The data of Thomsen¹⁵ and Berthelot^{10, 131} yield, for the heat of solution of potassium acetate, 3.34_{200} and 3.37_{200} , respectively.

$KCH_3O(CH_3OH)$. de Forcrand¹⁶ measured the heat of solution of K (c) in methyl alcohol.

$KC_2H_5O(C_2H_5OH)$. de Forcrand¹⁶ and van Deventer and Reicher² measured the heat of solution of K (c) in ethyl alcohol. Their data, respectively, yield for KC_2H_5O (60 C_2H_5OH), $Qf=116.49$, and for KC_2H_5O (427 C_2H_5OH), $Qf=117.64$.

$KC_2H_3O_3$ (aq.). de Forcrand³ measured the heat of neutralization of aqueous glycollic acid.

$KC_2H_3O_3 \cdot n H_2O$ (c). de Forcrand³ measured the heats of solution of the anhydrous salt and the hemihydrate of potassium glycollate.

KCN (aq.). Berthelot²⁷ measured the heat of neutralization of HCN(110) with KOH(110). His data yield $N=2.93_{220}$. Thomsen¹⁵ measured the heat of dilution from $62\frac{1}{2}$ to 150 H_2O .

KCN (c). The data of Berthelot¹⁰ and Thomsen¹⁵ yield, respectively, for the heat of solution, -2.93_{200} and -3.08_{1740} .

KCNO (aq.). The data of Berthelot¹⁰⁹ yield $N=12.2$.

KCNO (c). The heat of solution was measured by Berthelot.¹⁰

KCNS (aq.). The data of Joannis¹ yield $N=14.0$. Partington and Soper¹ measured the heat of dilution at 25° in the range 2.3 to 200 H_2O . We have converted their data to 18° and extrapolated to infinite dilution.

KCNS (c). The heat of solution data yield the following values for S_{200} : Joannis,¹ -5.98 ; Wrzesnewsky,¹ -6.22 ; Partington and Soper,¹ -6.00 .

$KCNS \cdot nSO_2$ (c). Ephraim and Kornblum¹ found for $n=\frac{1}{2}$, $D=-11.3$, and for $n=1$, $D=-9.9$.

K_2SiF_6 (c). Truchot² measured the heat of reaction of H_2SiF_6 (330) with $2KOH$ (110), and of SiF_4 (g) with $2KF$ (aq.); Hantke,¹ that of H_2SiF_6 (220) with $2KOH$ (110). Their data yield, respectively, for K_2SiF_6 (c), $Qf=683.9$, 684.5 , and 682.1 .

K_2SnCl_6 (aq.). Thomsen¹⁵ measured the heat of mixing $2KCl$ (150) with $SnCl_4$ (300).

K_2SnCl_6 (c). The heat of solution was measured by Thomsen.¹⁵

$K_2SnCl_6 \cdot H_2O$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{KCl} \cdot n\text{PbCl}_2 \cdot m\text{H}_2\text{O}$ (c). Brönsted,¹⁰ from electromotive force measurements, determined the heat of reaction of KCl (c) with PbCl_2 (c) and H_2O (liq.) to form $\text{KCl} \cdot 2\text{PbCl}_2$ (c) and $\text{KCl} \cdot \text{PbCl}_2 \cdot \frac{1}{3}\text{H}_2\text{O}$ (c), respectively.

$2\text{KI} \cdot \text{PbI}_2 \cdot n\text{H}_2\text{O}$ (c). Berthelot⁸⁹ measured the heats of solution of the anhydrous salt and the dihydrate.

$4\text{KI} \cdot 3\text{PbI}_2 \cdot n\text{H}_2\text{O}$ (c). Berthelot⁸⁹ measured the heats of solution of $4\text{KI} \cdot 3\text{PbI}_2$ (c, fresh melt) and the hexahydrate.

$\text{K}_2\text{SO}_4 \cdot \text{PbSO}_4$ (c). The data of Barre,¹ who measured the heats of solution of $\text{K}_2\text{SO}_4 \cdot \text{PbSO}_4$ (c) and of K_2SO_4 (c) + PbSO_4 (c), and Brönsted,⁹ who measured the heats of solution of the double salt and of K_2SO_4 (c) in $\text{Pb}(\text{NO}_3)_2$ (aq.), yield, for K_2SO_4 (c) + PbSO_4 (c) = $\text{K}_2\text{SO}_4 \cdot \text{PbSO}_4$ (c), $Q = -0.02$ and 5.30 , respectively. From electromotive force measurements, Brönsted⁹ found $Q = 5.09$.

$\text{K}_2\text{Zn}(\text{SO}_4)_2 \cdot n\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heats of solution of the anhydrous salt, the dihydrate, and the hexahydrate. The first data on the anhydrous salt and the hexahydrate were obtained by Graham.² The vapor pressure data of Caven and Ferguson² yield, for the hexahydrate, $Q_f = 1010.9$.

$2\text{KCN} \cdot \text{Zn}(\text{CN})_2$ (c). Berthelot¹¹⁴ measured the heat of solution.

KHg_n (liq.). The data of Berthelot,⁵⁶ Lewis and Keyes,¹ and Smith and Ball,¹ yield, respectively: $n = 57.5$, $Q_f = 25.6$; $n = 86.5$, $Q_f = 26.0$; $n = 145$, $Q_f = 25.9$.

KHg_n (c). Berthelot⁵⁵ measured the heat of solution of $\text{KHg}_{2.59}$ (c) in H_2O and in HCl (200), and (Berthelot⁵⁶) of four solid amalgams, with n ranging from 1.45 to 12.0, in HCl (300).

$n\text{KCl} \cdot \text{HgCl}_2$ (aq.). Berthelot⁸³ measured the heat of mixing HgCl_2 (440) with $\frac{1}{2}$, $\frac{3}{4}$, 1, 2, and 4 moles of KCl (110), respectively; Thomsen¹⁵ that of HgCl_2 (c) with 2KCl (150).

$n\text{KCl} \cdot \text{HgCl}_2 \cdot m\text{H}_2\text{O}$ (c). Berthelot⁸³ measured the heats of solution of $\text{KCl} \cdot \text{HgCl}_2$ (c) and its monohydrate, $2\text{KCl} \cdot \text{HgCl}_2$ (c), $4\text{KCl} \cdot 3\text{HgCl}_2$ (c) and its trihydrate, and $2\text{KCl} \cdot \text{HgCl}_2 \cdot \text{H}_2\text{O}$ (c). Thomsen¹⁵ also measured the heat of solution of the last named compound and, for it, their data yield the values: Thomsen, -16.43_{600} ; Berthelot, -16.53_{970} .

$n\text{KBr} \cdot \text{HgBr}_2$ (aq.). Berthelot⁸³ measured the heats of mixing KBr (110) with HgBr_2 (4400); Varet⁶ of KBr (220) with HgBr_2 (4400). Thomsen¹⁵ measured the heat of solution of HgBr_2 (c) in 2KBr (150).

$n\text{KBr} \cdot \text{HgBr}_2 \cdot m\text{H}_2\text{O}$ (c). Berthelot⁸³ measured the heats of solution of $\text{KBr} \cdot \text{HgBr}_2$ (c) and of its monohydrate, in 5KBr (110). Thomsen¹⁵ measured the heat of solution of $2\text{KBr} \cdot \text{HgBr}_2$ (c).

$n\text{KI} \cdot \text{HgI}_2$ (aq.). Berthelot⁸⁵ measured the heat of solution of HgI_2 (c, red) in 2, 3, 4, and 6 moles of KI (110); Thomsen¹⁵ that in 2KI (200) + $500\text{H}_2\text{O}$.

$n\text{KI} \cdot \text{HgI}_2 \cdot m\text{H}_2\text{O}$ (c). Berthelot⁸³ measured the heats of solution of $\text{KI} \cdot \text{HgI}_2$ (c) and of its monohydrate, in 13KI (110); Thomsen¹⁵ that of $2\text{KI} \cdot \text{HgI}_2$ (c) in water.

$n\text{KCN} \cdot \text{Hg}(\text{CN})_2 (\text{aq.})$. Berthelot⁸⁵ measured the heats of mixing $\text{Hg}(\text{CN})_2(440)$ with $\frac{1}{2}$, 1, 2, 4, 8, and 16 moles of $\text{KCN}(110)$; Varet² that with 1 and 2 moles of $\text{KCN}(110)$.

$2\text{KCN} \cdot \text{Hg}(\text{CN})_2 (\text{c.})$. Berthelot¹⁰ measured the heat of solution.

$n\text{KCl} \cdot \text{Hg}(\text{CN})_2 (\text{aq.})$. Berthelot⁸⁶ measured the heats of mixing $\text{Hg}(\text{CN})_2(440)$ with $\frac{1}{2}$, 1, 2, 4, and 8 moles of $\text{KCl}(110)$; Varet² that with 2 moles of $\text{KCl}(110)$.

$\text{KCl} \cdot \text{Hg}(\text{CN})_2 \cdot n\text{H}_2\text{O} (\text{c.})$. Berthelot⁸⁵ measured the heat of solution of the anhydrous salt and of its monohydrate.

$n\text{KBr} \cdot \text{Hg}(\text{CN})_2 (\text{aq.})$. Berthelot⁸³ measured the heats of mixing $\text{Hg}(\text{CN})_2(440)$ with $\frac{1}{2}$, 1, 2, 4, and 8 moles of $\text{KBr}(110)$; Varet² those with 1 and 2 moles of $\text{KBr}(110)$.

$\text{KBr} \cdot \text{Hg}(\text{CN})_2 \cdot n\text{H}_2\text{O} (\text{c.})$. Berthelot⁸³ measured the heats of solution of the anhydrous salt and the hydrate with $1\frac{1}{2}$ moles of H_2O .

$n\text{KI} \cdot \text{Hg}(\text{CN})_2 (\text{aq.})$. Berthelot⁸³ measured the heats of mixing $\text{Hg}(\text{CN})_2(440)$ with $\frac{1}{2}$, 1, 2, 4, and 8 moles of $\text{KI}(110)$; Varet² that with 2 moles of $\text{KI}(110)$.

$\text{KI} \cdot \text{Hg}(\text{CN})_2 \cdot n\text{H}_2\text{O} (\text{c.})$. Berthelot⁸³ measured the heats of solution of the anhydrous salt and the hydrate with $\frac{1}{4}\text{H}_2\text{O}$.

$\text{KCl} \cdot \text{CuCl}_2 (\text{c.})$. Vriens¹ measured the heat of solution of this double salt; Agostini,¹ that of the double salt, of $\text{CuCl}_2 (\text{c.})$, and of $\text{KCl} (\text{c.})$. Their data yield, respectively, $Q_f=159.8$ and 162.4 .

$2\text{KCl} \cdot \text{CuCl}_2 (\text{c.})$. The electromotive force data of Brönsted¹⁰ yield $Q_f=244.78$.

$2\text{KCl} \cdot \text{CuCl}_2 (\text{c.})$. Bouzat and Chauvenet² measured the heat of solution of $2\text{KCl} \cdot \text{CuCl}_2 (\text{c.})$; Agostini¹ that of $2\text{KCl} \cdot \text{CuCl}_2 (\text{c.})$, of $\text{KCl} (\text{c.})$, and of $\text{CuCl}_2 (\text{c.})$. Their data yield, respectively; $Q_f=265.7$ and 266.2 .

$2\text{KCl} \cdot \text{CuCl}_2 \cdot 2\text{H}_2\text{O} (\text{c.})$. Bouzat and Chauvenet² measured the heat of solution, as did Vriens¹ and Favre and Valson.¹ The data of Bouzat and Chauvenet, and Vriens, yield, respectively, $Q_f=407.5$ and 407.0 .

$\text{K}_2\text{Cu}(\text{SO}_4)_2 (\text{c}, \alpha)$ (prepared below 130°). The data of Thomsen¹⁵ and Pickering⁴ yield, respectively, for the heat of solution: 9.48_{600} and 9.67_{800} .

$\text{K}_2\text{Cu}(\text{SO}_4)_2 (\text{c}, \beta)$ (prepared between 180 and 200°). The data of Pickering⁴ yield $S=6.23_{800}$.

$\text{K}_2\text{Cu}(\text{SO}_4)_2 (\text{c}, \text{fused})$. The data of Pickering⁴ yield $S=8.37_{800}$. Graham² also measured the heat of solution.

$\text{K}_2\text{Cu}(\text{SO}_4)_2 \cdot 2\text{H}_2\text{O} (\text{c.})$. The data of Thomsen¹⁵ yield $S=-1.17_{600}$.

$\text{K}_2\text{Cu}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O} (\text{c.})$. Data on the heat of solution were reported by Graham² and Favre.⁸ The data of Thomsen¹⁵ and Pickering⁵ yield $S=-13.50_{600}$ and -13.77_{800} , respectively. The dissociation pressure data of Caven and Ferguson¹ yield $Q_f=962.7$.

$\text{K}_2\text{Cu}(\text{CO}_3)_2 (\text{c.})$. Pickering¹¹ measured the heat of solution of three crystalline forms of this double salt in $\text{HCl}(35)$.

$n\text{KX} \cdot n'\text{AgX} \cdot m\text{H}_2\text{O}$ (c). Berthelot⁸⁶ measured the heats of solution of $\text{KCl} \cdot \text{AgCl}$ (c), $\text{KBr} \cdot \text{AgBr}$ (c), $3 \text{KBr} \cdot \text{AgBr} \cdot \frac{1}{2} \text{H}_2\text{O}$ (c), $\text{KI} \cdot \text{AgI} \cdot \frac{1}{4} \text{H}_2\text{O}$ (c), $2 \text{KI} \cdot \text{AgI} \cdot \frac{1}{2} \text{H}_2\text{O}$ (c), $3 \text{KI} \cdot \text{AgI}$ (c), $3 \text{KI} \cdot \text{AgI} \cdot \frac{1}{2} \text{H}_2\text{O}$ (c), and $3 \text{KI} \cdot 2 \text{AgI} \cdot \text{H}_2\text{O}$ (c).

$\text{KAg}(\text{CN})_2$ (aq.). Varet⁵ measured the heat of solution of AgCN (c) in KCN (550).

$\text{KAg}(\text{CN})_2$ (c). Berthelot¹⁰ measured the heat of solution of $\text{KAg}(\text{CN})_2$ (c), and the heat of mixing AgNO_3 (440) with 2KCN (110).

$\text{K}_2\text{Ag}(\text{CN})_3$ (aq.). Varet⁵ measured the heats of solution of AgCN (c) in 2KCN (110), 2KCN (165), and 2KCN (660), respectively.

$\text{KAu}(\text{CN})_2$ (aq.). Biltz and Wien¹ measured the heat of solution of AuCl (c) in excess KCN (aq.).

$\text{K}_2\text{Ni}(\text{CN})_4$ (aq.). Varet⁵ measured the heat of solution of $\text{Ni}(\text{CN})_2$ (c) in 2KCN (aq.).

$\text{K}_2\text{CO}_3 \cdot \text{CoCO}_3 \cdot n\text{H}_2\text{O}$ (c). de Carli¹ measured the heats of solution of the anhydrous salt and the tetrahydrate in HCl (314).

$\text{KFe}(\text{SO}_4)_2$ (aq.). Thomsen¹⁵ measured the heat of mixing $\text{KFe}(\text{SO}_4)_2$ (600) with 3KOH (400).

$\text{K}_2\text{Fe}(\text{SO}_4)_2$ (aq.). Berthelot¹⁰⁰ measured the heat of mixing FeSO_4 (220) with K_2SO_4 (220).

$\text{K}_3\text{Fe}(\text{SO}_4)_3$ (aq.). Berthelot¹⁰⁰ measured the heat of mixing $\text{Fe}_2(\text{SO}_4)_3$ (660) with $3\text{K}_2\text{SO}_4$ (220).

$\text{K}_2\text{Fe}(\text{SO}_4)_2 \cdot 6 \text{H}_2\text{O}$ (c). The data of Graham¹ yield $S = 10.3_{200}$.

$\text{K}_2\text{Fe}(\text{SO}_4)_2 \cdot 4 \text{H}_2\text{O}$ (c). Caven and Ferguson² measured the dissociation pressure of the hexahydrate at various temperatures. Their data yield $D = -10.4$.

$\text{K}_n\text{H}_{3-n}\text{Fe}(\text{CN})_6$ (aq.). Joannis¹ measured the heat of reaction of $\text{K}_4\text{Fe}(\text{CN})_6$ (aq.) with $\frac{1}{2} \text{Br}_2$ (liq.), $\text{K}_4\text{Fe}(\text{CN})_6$ (aq.) with $\frac{1}{2} \text{Cl}_2$ (g), $\text{H}_3\text{Fe}(\text{CN})_6$ (aq.) with KOH (aq.), and $\text{H}_3\text{Fe}(\text{CN})_6$ (aq.) with 2KOH (aq.). These data yield, respectively, the values for the heats of formation of $\text{K}_3\text{Fe}(\text{CN})_6$ (aq.), $\text{KH}_2\text{Fe}(\text{CN})_6$ (aq.), and $\text{K}_2\text{HFe}(\text{CN})_6$ (aq.).

$\text{K}_3\text{Fe}(\text{CN})_6$ (c). Joannis¹ measured the heat of solution.

$\text{K}_4\text{Fe}(\text{CN})_6$ (aq.). The data of Joannis,¹ Muller,² and Chretien and Guinchant¹ yield, respectively, for N : 55.1; 56.08₁₃₉₀; 57.5₅₂₀₀. Muller's² data yield, for $\text{K}_4\text{Fe}(\text{CN})_6$ (aq.), $Q_f = 119.50$.

$\text{K}_n\text{H}_{4-n}\text{Fe}(\text{CN})_6$ (aq.). Muller² measured the heat of mixing $\text{H}_4\text{Fe}(\text{CN})_6$ (aq.) with 1, 2, and 3 moles of KOH (aq.).

$\text{K}_4\text{Fe}(\text{CN})_6$ (c). Berthelot¹⁰ found $S = -11.96_{510}^{12}$; Schottky,¹ $S = -12.39_{1000}^{17}$.

$\text{K}_4\text{Fe}(\text{CN})_6 \cdot 3 \text{H}_2\text{O}$ (c). Berthelot¹⁰ found $S = -16.92_{590}^{11}$; Schottky,¹ $S = -15.69_{1000}^{17}$.

$\text{K}_3\text{FeCO}(\text{CN})_5$ (aq.). Muller⁹ found $N = 42.0$.

$\text{K}_3\text{FeCO}(\text{CN})_5 \cdot n\text{H}_2\text{O}$ (c). Muller⁹ measured the heats of solution of the anhydrous salt and the hydrate with $3\frac{1}{2} \text{H}_2\text{O}$.

KMnO_4 (aq.). Thomsen¹⁵ measured the heats of reaction of 2KMnO_4 (aq.) with 10FeCl_2 (aq.), with $5 \text{H}_2\text{O}_2$ (aq.), and with 5SnCl_2 (aq.),

respectively, and his data yield, for KMnO_4 (aq.), the average value $Qf=182.5$.

KMnO_4 (c). The data of Thomsen¹⁵ yield -10.42_{500} and -10.10_{700} for the heat of solution.

KReO_4 (aq.). Roth and Becker⁴ measured the heat of neutralization of HReO_4 (aq.), and gave the value $N_{\infty}^{20}=13.5\pm0.1$. Converted to 18° , this value becomes 13.61 ± 0.1 . From the ions we have calculated, for KReO_4 (∞), $Qf=284.5$. We have estimated the heat of dilution of aqueous KReO_4 from the data of Roth and Becker⁴ on the heat of solution of the solid salt.

KReO_4 (c). The data of Roth and Becker⁴ yield -13.88_{3800} for the heat of solution.

$\text{K}_2\text{Mn}(\text{SO}_4)_2 \cdot n\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heats of solution of the anhydrous salt, the dihydrate, and the tetrahydrate.

K_2PdCl_4 (aq.). Thomsen¹⁵ measured the heat of reaction of K_2PdCl_4 (1400) with Co (c) and 2 CuCl (c), respectively; Joannis,⁴ that of K_2PdCl_4 (aq.) with 2 CuCl (c). Their data yield, respectively, $Qf=247.8$, 248.9 , and 251.4 .

K_2PdCl_4 (c). Thomsen¹⁵ found $S=-13.64_{800}^{19.5}$; Joannis,⁴ $S=-4.6$ (?).

K_2PdCl_6 (c). Thomsen¹⁵ measured the heat of reaction of K_2PdCl_6 (c) with 4 KI (400), and with 4 CuCl (c) in water. His data yield, respectively, $Qf=291.26$ and 292.95 .

K_2PdCl_6 (aq.). Thomsen¹⁵ estimated the heat of solution.

K_2PdBr_4 (aq.). Joannis⁴ measured the heat of reaction of Pd (c) with Br_2 (liq.) and 2 KBr (aq.).

K_2PdBr_4 (c). Joannis⁴ measured the heat of solution.

K_2PtCl_4 (c). Thomsen¹⁵ measured the heat of reaction of K_2PtCl_4 (c) with Co (c) in water.

K_2PtCl_4 (aq.). Thomsen¹⁵ measured the heat of solution of K_2PtCl_4 (c).

K_2PtCl_6 (aq.). Thomsen¹⁵ measured the heat of reaction of Na_2PtCl_6 (c) with 2 KCl (100); Gire² that of K_2PtCl_6 (aq.) with 2 Co (c). Their data yield, respectively, $Qf=286.2$ and 289.7 .

K_2PtCl_6 (c). The data of Thomsen¹⁵ yield for the reaction, Na_2PtCl_6 (aq.) + 2 KCl (aq.) = K_2PtCl_6 (c) + 2 NaCl (aq.), $Q=13.42$. Hence, $S=-13.42$. Gire² found $S=-12.15_{600}^{12.5}$. Gire's¹ data on the dissociation pressure of K_2PtCl_6 (c) yield $Qf=291$.

K_2PtBr_4 (aq.). Thomsen¹⁵ measured the heat of reaction of K_2PtBr_4 (1500) with Br_2 (liq.), and of K_2PtBr_4 (750) with Co (c). His data yield, respectively, $Qf=210.77$ and 210.72 .

K_2PtBr_4 (c). Thomsen¹⁵ measured the heat of solution.

K_2PtBr_6 (c). Thomsen¹⁵ measured the heat of reaction of K_2PtBr_6 (c) with 2 Co (c) in water.

K_2PtBr_6 (aq.). Thomsen¹⁵ measured the heat of solution of K_2PtBr_6 (c).

K₂IrCl₆ (c). The data of Gire¹ on the dissociation pressure-temperature relationship yield $Q_f = 286$.

K₂IrCl₆ (aq.). Gire² measured the heat of solution of K₂IrCl₆ (c).

K₃IrCl₆ (aq.). Gire² measured the heat of the reaction, K₂IrCl₆ (aq.) + $\frac{1}{2}$ Co (c) + KCl (aq.) = (K₃IrCl₆ + $\frac{1}{2}$ CoCl₂) (aq.).

K₃IrCl₆ (c). Gire² measured the heat of solution. His data (Gire¹) on the dissociation pressure yield $Q_f = 373$.

K₂CrO₄ (aq.). The data of Morges¹ yield $N = 22.78_{440}$; those of Sabatier⁵ yield $N = 25.4_{440}$. The heat of dilution was measured by Roth, Schwartz, and Buchner.¹

K₂CrO₄ (c, II). Graham² and Morges¹ measured the heat of solution, the data of the latter yielding $S = -5.25_{543}$.

K₂CrO₄ (c, I). Hare¹ measured the heat of transition.

K₂Cr₂O₇ (aq.). Morges¹ measured the heat of mixing CrO₃(220) with KOH(110); Berthelot,⁹⁵ K₂Cr₂O₇(660) with 2 KOH(110), and 2 K₂CrO₄(220) with 2 HCl(110); Sabatier,⁵ CrO₃(220) with KOH(110), and K₂Cr₂O₇(220) with 2 KOH(110). Their data yield, respectively, for K₂Cr₂O₇(400), $Q_f = 469.8, 471.6, 471.4, 471.8$, and 471.8. The data of Stackelberg¹ give the heat of dilution.

K₂Cr₂O₇ (c). The data on the heat of solution yield the following values for S_{400} : Graham,² (?); Morges,¹ -16.61 ; Berthelot,⁹⁵ -16.20 ; Thomsen,¹⁵ -16.70 ; Stackelberg,¹ -16.68 . We have selected the average of the last two values.

KCl · CrO₃ (c). Morges¹ measured the heat of solution.

K₂Cr₂O₇ · CrO₃ (c). Graham² measured the heat of solution.

KCr(SO₄)₂ (aq.). Thomsen¹⁵ measured the heat of mixing KCr(SO₄)₂(600) with 3 KOH(400).

KCr(SO₄)₂ · nH₂O (c). Thomsen¹⁵ measured the heat of solution of the dodecahydrate. Kraus, Fricke, and Querengasser¹ measured the vapor pressures of the various hydrates over a range of temperature.

KNH₄CrO₄ (aq.). Sabatier⁵ measured the heat of mixing K₂Cr₂O₇(440) with 2 NH₃(110).

KNH₄CrO₄ (c). Sabatier⁵ measured the heat of solution.

K₂MoO₄ (aq.). Pechard¹ found, for H₂MoO₄ (c) + 2 KOH(440), $N = 24.1$.

2 KCl · UOCl₂ · 2 H₂O (c). Aloy¹ measured the heat of solution.

KVO₅ (aq.). This value is obtained from those for the aqueous ions.

KVO₃ (aq.), KVO₄ (aq.). Pissarjewsky⁴ measured the heat of mixing KVO₃ (aq.) with 2 H₂O₂ (aq.) and H₂O₂ (aq.), respectively.

KVO₃ (c), KVO₄ (c). Pissarjewsky⁴ measured the heats of solution.

nKCl · ThCl₄ · mH₂O (c). Chauvenet² measured the heats of solution of 2 KCl · ThCl₄ (c) and KCl · ThCl₄ · 9 H₂O (c).

3 KF · AlF₃ (aq.). The data of Baud¹ yield for the heat of mixing 3 KF (aq.) with AlF₃ (aq.), $Q = -1.51$.

3 KF · AlF₃ · nH₂O (c). Baud¹ measured the heats of solution of the anhydrous salt and the hydrate with $3\frac{1}{2}$ H₂O.

$n\text{KCl} \cdot \text{AlCl}_3$ (c). Baud¹ measured the heats of solution of $\text{KCl} \cdot \text{AlCl}_3$ (c), $3\text{KCl} \cdot \text{AlCl}_3$ (c), and $3\text{KCl} \cdot 2\text{AlCl}_3$ (c).

$\text{KCl} \cdot \text{AlCl}_3 \cdot 6\text{NH}_3$ (c). Baud¹ measured the heat of solution.

$\text{KAl}(\text{SO}_4)_2$ (aq.). Thomsen¹⁵ measured the heat of mixing $\text{KAl}(\text{SO}_4)_2$ (600) with 3KOH (400).

$\text{KAl}(\text{SO}_4)_2 \cdot n\text{H}_2\text{O}$ (c). Favre and Silbermann³ and Thomsen¹⁵ measured the heat of solution of the dodecahydrate, the latter's data yielding $S = -10.10_{800}$. The heats of dehydration have been calculated from the vapor pressure data of Kraus, Fricke, and Querengasser.¹ See also Ephraim and Wagner.¹

$\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot n\text{SiO}_2$ (solid). Mulert¹ measured the heats of solution, in 20% HF (aq.), of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ (c, leucite), of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ (c, adular), and of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ (gls.); Tammann (as reported by Mulert¹) those of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ (c, leucite), of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ (gls.), of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ (c, microcline), and of $\text{K}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ (gls.). For the first substance the respective data yield, $Q_f = 1379.8$ and 1374.7 ; for the last substance, $Q_f = 1754.9$ and 1738.0 .

$n\text{KCl} \cdot \text{MgCl}_2 \cdot m\text{H}_2\text{O}$ (c, fresh melt). Berthelot and Ilosvay¹ measured the heats of solution of the fresh melts of $\text{KCl} \cdot \text{MgCl}_2$ (c), $\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ (c), $2\text{KCl} \cdot \text{MgCl}_2$ (c), and $4\text{KCl} \cdot \text{MgCl}_2$ (c).

$\text{K}_2\text{Mg}(\text{SO}_4)_2$ (c) (prepared below 150°). Pickering⁴ found $S = 11.53_{800}$; Thomsen,¹⁵ $S = 10.62_{600}$.

$\text{K}_2\text{Mg}(\text{SO}_4)_2$ (c) (fresh melt). The data of Berthelot and Ilosvay,¹ and Pickering⁴ yield, respectively, for S_{800} , 6.92 and 7.30.

$\text{K}_2\text{Mg}(\text{SO}_4)_2 \cdot 2\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{K}_2\text{Mg}(\text{SO}_4)_2 \cdot 4\text{H}_2\text{O}$ (c). Caven and Ferguson² measured the dissociation pressure over a range of temperature, finding $D = -10.4$.

$\text{K}_2\text{Mg}(\text{SO}_4)_2 \cdot 5\text{H}_2\text{O}$ (c). Thomsen¹⁵ measured the heat of solution.

$\text{K}_2\text{Mg}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$ (c). The data on the heat of solution yield for S_{800} : Graham,² (?); Thomsen,¹⁵ -10.10 ; Pickering,⁵ -9.94 .

$2\text{KCl} \cdot \text{CaCl}_2$ (c) (fresh melt). Berthelot and Ilosvay¹ measured the heat of solution.

$\text{K}_2\text{SO}_4 \cdot n\text{CaSO}_4 \cdot \text{H}_2\text{O}$ (c). Barre¹ measured the heats of solution of the following: $\text{K}_2\text{SO}_4 \cdot \text{CaSO}_4 \cdot \text{H}_2\text{O}$ (c), K_2SO_4 (c) + $\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$ (c), $\text{K}_2\text{SO}_4 \cdot 5\text{CaSO}_4 \cdot \text{H}_2\text{O}$ (c), and K_2SO_4 (c) + $5(\text{CaSO}_4 \cdot 2\text{H}_2\text{O})$ (c).

$\text{KCaFeCO}(\text{CN})_5 \cdot 5\text{H}_2\text{O}$ (c). Lecocq¹ measured the heat of combustion in a bomb calorimeter, finding $Q = 2152$.

$\text{K}_2\text{SO}_4 \cdot \text{SrSO}_4$ (c). Barre¹ measured the heats of solution of $\text{K}_2\text{SO}_4 \cdot \text{SrSO}_4$ (c) and of K_2SO_4 (c) + SrSO_4 (c).

KLiClI (c) (fresh melt). Beketoff⁸ measured the heats of solution of the fresh melt, of LiCl (c) + KI (c), and of LiI (c) + KCl (c).

$\text{NaCl} \cdot \text{KCl}$ (c) (fresh melt). Beketoff⁸ measured the heats of solution of the fresh melt and of NaCl (c) + KCl (c).

KNaClI (c) (fresh melt). Beketoff⁸ measured the heats of solution of the fresh melt, of NaCl (c) + KI (c), and of NaI (c) + KCl (c).

Na_nK_m (liq.). Joannis² measured the heats of solution of Na (c), K (c), NaK (liq.), NaK₂ (liq.), NaK₃ (liq.), and Na₂K (liq.) in water.

Na_2KPO_4 (aq.). Berthelot and Louguinine³ measured the heat of mixing Na₂HPO₄(220) with KOH(110).

3 KCNS · NaCNS (c). Wrzesnewsky¹ measured the heats of solution of KCNS (c), of NaCNS (c), and of 3 KCNS · NaCNS (c).

RUBIDIUM

Rb (c). Standard state.

Rb (liq.). The data on the heat of fusion are: Rengade,⁴ -0.524^{39} ; Bridgman,¹ -0.552^{39} .

Rb (g). Vapor pressure data were reported by Hackspill¹ and Kilian.¹ See also van Laar.⁹ The values for the energy states of gaseous monatomic rubidium are from Fowler,³ Miller and Laporte,¹ and Bacher and Goudsmit.¹

RbOH (aq.). The heat of solution of Rb (c) in water was measured by Beketoff³ and Rengade.¹ Their data yield, respectively, for Rb (c) + H₂O (liq.) = RbOH(200) + $\frac{1}{2}$ H₂ (g), $Q = 48.2$ and 47.3 . Taking the latest value, we have obtained, for LiOH(200), $Q_f = 115.7$. de Forcrand⁵⁵ measured the heat of dilution of RbOH (aq.) from 3.18 to 223 H₂O. We have estimated the heat of dilution from 200 to ∞ H₂O to be zero.

Rb⁺ (∞). The foregoing data give for Rb⁺ (∞) + OH⁻ (∞), $Q_f = 115.7$; whence, for Rb⁺ (∞), $Q_f = 61.04$.

RbOH · n H₂O (c). de Forcrand⁴⁴ measured the heats of solution of RbOH (c, II), RbOH · 0.613 H₂O, and RbOH · H₂O (c); and later (de Forcrand⁵⁵) that of RbOH · 2 H₂O (c).

RbOH (c, I). Hevesy¹ measured the heat of transition.

Rb₂O (c). Rengade³ measured the heat of solution in H₂O. The similar data of Beketoff³ are somewhat doubtful.

Rb₂O_n (c). de Forcrand⁶⁶ estimated the heats of formation of Rb₂O₂ (c) and Rb₂O₄ (c).

RbH (c). Kasarnowsky¹ quoted unpublished values of Monosohn, giving $Q_f = 12$.

RbF (aq.). From the ions, we have obtained, for RbF (∞), $Q_f = 139.24$. Lange and Monheim² measured the heat of dilution of RbF (aq.) in the very dilute region, and their data have been converted to 18° giving values from ∞ to 100 H₂O.

RbF (c). de Forcrand⁵⁷ measured the heat of solution.

RbF (liq.). We have estimated the heat of fusion.

RbF (g). The vapor pressure of RbF was measured by Von Wartenberg and Schulz¹ and Ruff, Schmidt, and Mugdan.¹

RbF · n H₂O (c). de Forcrand⁵⁹ measured the heats of solution of RbF · $\frac{1}{3}$ H₂O (c) and RbF · $1\frac{1}{2}$ H₂O (c).

RbHF₂ (aq.). From the ions, we have obtained $Q_f = 214.4$.

RbHF₂ (c). de Forcrand⁶⁰ measured the heat of solution.

RbCl (aq.). From the ions, we have obtained, for $\text{RbCl}(\infty)$, $Q_f = 100.727$. The heat of dilution has been estimated from ∞ to $100 \text{ H}_2\text{O}$.

RbCl (c). The data on the heat of solution have been recomputed to give the following values for S_{200} : de Forcrand,⁴⁶ -4.36 ; Zemczuzny and Rambach,¹ -4.43 ; Haigh,¹ -4.34 .

RbCl (liq.). We have estimated the heat of fusion.

RbCl (g). Vapor pressure data were reported by von Wartenberg and Schulz¹ and Ruff and Mugdan.¹ See also Sommermeyer.¹

RbBr (aq.). From the ions, we have obtained, for $\text{RbBr}(\infty)$, $Q_f = 89.71$. We have estimated the heat of dilution in the range ∞ to $100 \text{ H}_2\text{O}$.

RbBr (c). de Forcrand⁵⁷ measured the heat of solution.

RbBr (liq.). Plato^{1, 2} measured the heat of fusion.

RbBr (g). Vapor pressure data were reported by von Wartenberg and Schulz¹ and Ruff and Mugdan.¹

RbI (aq.). From the ions, we have obtained for $\text{RbI}(\infty)$, $Q_f = 74.41$. We have estimated the heat of dilution from ∞ to $100 \text{ H}_2\text{O}$.

RbI (c). The data on the heat of solution yield the following values for S_{200} : de Forcrand,^{12, 57} -6.55 ; Mosnier,¹ -5.86 .

RbI (liq.). We have estimated the heat of fusion.

RbI (g). Vapor pressure data were reported by von Wartenberg and Schulz¹ and Ruff and Mugdan.¹ Sommermeyer,¹ from absorption spectra of $\text{RbI}(\text{g})$, estimated $D^{\circ} = -77.5$.

Rb_2S (aq.). Rengade and Costeaunu² measured the heat of neutralization of $\text{RbOH}(\text{aq.})$ with $\text{H}_2\text{S}(\text{aq.})$. Their data yield, for $\text{Rb}_2\text{S}(550)$, $Q_f = 112.5$. From the ions, we have obtained for $\text{Rb}_2\text{S}(\infty)$, $Q_f = 112.08$.

Rb_2S (c). Rengade and Costeaunu² measured the heat of solution.

Rb_2SO_4 (aq.). deForcrand⁴⁶ measured the heat of neutralization of $\text{RbOH}(\text{aq.})$ with $\text{H}_2\text{SO}_4(\text{aq.})$. His data, combined with the heat of dilution, give, for $\text{Rb}_2\text{SO}_4(\infty)$, $Q_f = 337.64$. From the ions, we have obtained 337.88 . Lange and Streeck¹ measured the heat of dilution at 25° . We have used their data to obtain values at 18° from ∞ to $200 \text{ H}_2\text{O}$.

Rb_2SO_4 (c). deForcrand⁴⁶ measured the heat of solution.

RbHSO_4 (aq.). deForcrand⁴⁶ measured the heat of reaction of $\text{RbOH}(110)$ with $\text{H}_2\text{SO}_4(220)$, and of $\text{RbHSO}_4(330)$ with $\text{RbOH}(110)$. His data yield, for $\text{RbHSO}_4(330)$, $Q_f = 274.09$ and 274.42 , respectively.

RbHSO_4 (c). deForcrand⁴⁶ measured the heat of solution.

$\text{RbI} \cdot 4\text{SO}_2$ (c). The data of Ephraim and Kornblum¹ and deForcrand and Taboury,¹ on the temperature coefficient of the dissociation pressure, give, respectively, $D = -10.1$ and -10.1 .

RbNO_3 (aq.). From the ions, we have computed for $\text{RbNO}_3(\infty)$, $Q_f = 110.23$. We have estimated the heat of dilution for the range ∞ to $100 \text{ H}_2\text{O}$.

RbNO_3 (c, II). Haigh¹ measured the heat of solution.

RbNO_3 (c, I). Bridgman^{6a} measured the heat of transition.

RbX · nNH₃ (c). Biltz and Hansen¹ measured the temperature coefficient of the dissociation pressures of RbBr · 3NH₃(c) and RbI · 6NH₃(c).

Rb₂CO₃ (aq.). deForcrand⁴⁹ measured the heat of neutralization of RbOH (aq.) with CO₂ (aq.) His data, together with the heat of dilution, give for Rb₂CO₃ (∞), $Q_f = 282.76$. From the ions, we have obtained 282.58. deForcrand⁵² measured the heat of dilution of Rb₂CO₃(aq.), from 5.76 to 226 H₂O. We have estimated the heats of dilution to 2000 and ∞ H₂O.

Rb₂CO₃ (c). deForcrand^{49, 52} measured the heat of solution, and LeBeau¹ obtained data on the dissociation pressure at various temperatures.

Rb₂CO₃ · nH₂O (c). deForcrand⁵² measured the heats of solution of Rb₂CO₃ with 1, 1½, and 3½ moles of H₂O.

RbHCO₃ (aq.). deForcrand⁵³ measured the heat of reaction of RbOH(110) with CO₂(1800). His data yield for RbHCO₃(1800), $Q_f = 225.91$.

RbHCO₃ (c). deForcrand⁵³ measured the heat of solution. His data yield $Q_f = 230.44$. The data of Caven and Sand² on the dissociation pressure at various temperatures yield $Q_f = 232.8$.

3(Rb₂CO₃ · 1½ H₂O) · 2 RbHCO₃ (c). de Forcrand⁵⁴ measured the heat of solution.

RbCNS (aq.). From the ions, we have obtained $Q_f = 42.0$.

RbCNS (c). The heat of solution is estimated to be -14 .

RbCNS · ½ SO₂ (c). Ephraim and Kornblum¹ reported $D = -10.6$.

2RbI · PbI₂ · nH₂O (c). Mosnier¹ measured the heats of solution of the anhydrous salt and the tetrahydrate.

2RbCl · CuCl₂ · nH₂O (c). Bouzat and Chauvenet² measured the heats of solution of the anhydrous salt and the dihydrate.

nRbCl · ThCl₄ · mH₂O (c). Chauvenet² measured the heat of solution of 2RbCl · ThCl₄ (c), 2RbCl · ThCl₄ · 9H₂O (c), and 4RbCl · ThCl₄ (c).

RbAl(SO₄)₂ · nH₂O (c). For the dodecahydrate we have estimated the heat of solution to be -11 . The heats of dissociation of the various hydrates have been calculated from the dissociation pressure data of Kraus, Fricke, and Querengasser¹ and Ephraim and Wagner.¹

CESIUM

Cs (c). Standard state.

Cs (liq.). The data on the heat of fusion are: Rengade,¹ $-0.501^{28,5}$; Bridgman,¹ -0.51^{28}

Cs (g). Vapor pressure data were reported by Hackspill,¹ Kroner,¹ Scott,¹ and Langmuir and Kingdom.¹ See also Boer and Dippel,¹ van Laar,⁹ and Egerton.³ The values for the energy states of gaseous monatomic cesium are from Fowler,³ Miller and Laporte,¹ and Bacher and Goudsmit.¹

CsOH (aq.). The heat of solution of Cs (c) in water was measured by Beketoff^{4, 6} and Rengade.¹ Their data yield, for Cs (c) + H₂O (liq.) = CsOH(200) + $\frac{1}{2}$ H₂ (g), $Q = 51 \pm 1$ and 48.32 ± 0.10 , respectively. Taking Rengade's value, we have computed, for CsOH(200), $Q_f = 116.7$. deForcrand⁵⁵ measured the heat of dilution of CsOH (aq.) from 2.16 to 222 H₂O. We have estimated the heat of dilution from 200 to ∞ H₂O to be zero.

Cs⁺(∞). From the foregoing data we have obtained for Cs⁺(∞) + OH⁻(∞), $Q_f = 116.7$; whence, for Cs⁺(∞), $Q_f = 62.04$.

CsH (c). Kasarnowsky² quoted unpublished values of Monosohn, giving $Q_f = 12$.

CsOH (c, II). The heat of solution was measured by deForcrand⁴⁴ and by Beketoff.⁴ Their values yield, for S , 16.56_{110} and 16.0_{330} , respectively.

CsOH (c, I). Hevesy¹ measured the heat of transition.

CsOH · H₂O (c). deForcrand⁴⁴ measured the heat of solution.

Cs₂O (c). The heat of solution in H₂O was measured by Beketoff⁶ and Rengade.^{1, 3} Their values yield $S = 83.1_{3400}$ and 72.2_{1800} , respectively.

Cs₂O₄ (c). deForcrand⁵⁶ measured the heat of solution in H₂SO₄ (aq.).

CsF (aq.). From the ions, we have obtained, for CsF (∞), $Q_f = 140.24$. We have estimated the heat of dilution from 800, 200, and 100 H₂O to ∞ H₂O.

CsF (c). The heat of solution was measured by deForcrand.⁵⁷

CsF (liq.). We have estimated the heat of fusion.

CsF (g). Vapor pressure data were reported by von Wartenberg and Schulz¹ and Ruff, Schmidt, and Mugdan.¹

CsF · n H₂O (c). deForcrand⁵⁹ measured the heats of solution of CsF · $\frac{2}{3}$ H₂O (c) and CsF · $1\frac{1}{2}$ H₂O (c).

CsHF₂ (aq.). From the ions, we have computed $Q_f = 215.4$.

CsHF₂ (c). The heat of solution was measured by deForcrand.⁶⁰

CsCl (aq.). From the ions, we have obtained, for CsCl (∞), $Q_f = 101.727$. The heat of dilution was measured by Richards and Rowe³ at 18° from 25 to 400 H₂O, and by Lange and Messner¹ at 25° in the very dilute region. The latter values have been converted to 18° and combined with the former to give values from 25 to ∞ H₂O.

CsCl (c, II). The data on the heat of solution of CsCl (c) in H₂O yield the following values for S_{200} : deForcrand,⁴⁸ -4.61 ; deForcrand,^{12, 57} -4.54 ; Haigh,¹ -4.37 .

CsCl (c, I). Zemczuzny and Rambach¹ measured the heat of transition.

CsCl (liq.). We have estimated the heat of fusion.

CsCl (g). Vapor pressure data were reported by von Wartenberg and Schulz,¹ Ruff and Mugdan,¹ and Fiock and Rodebush.¹

CsBr (aq.). From the ions, we have obtained, for CsBr (∞), Q_f

=90.71. The heat of dilution has been estimated for the range ∞ to 100 H_2O .

CsBr (c). The heat of solution was measured by deForcrand.^{12, 57}

CsBr (liq.). We have estimated the heat of fusion.

CsBr (g). Vapor pressure data were reported by von Wartenberg and Schulz¹ and Ruff and Mugdan.¹ Sommermeyer¹ calculated, from absorption spectra, $D^\circ = -89.8$.

CsI (aq.). From the ions, we have obtained, for $\text{CsI}(\infty)$, $Q_f = 75.41$. We have estimated the heat of dilution from ∞ to 100 H_2O .

CsI (c). The heat of solution was measured by deForcrand.^{12, 57} His data give $S_{110} = -8.12$; whence, for $\text{CsI}(\text{c})$, $Q_f = 83.90$. Beketoff⁸ measured the heats of solution of $\text{NaCl}(\text{c}) + \text{CsI}(\text{c})$, $\text{NaI}(\text{c}) + \text{CsCl}(\text{c})$, $\text{KCl}(\text{c}) + \text{CsI}(\text{c})$, and $\text{KI}(\text{c}) + \text{CsCl}(\text{c})$. His data yield two identical values for the heat of formation of $\text{CsI}(\text{c})$, namely 83.88.

CsI (liq.). We have estimated the heat of fusion.

CsI (g). Vapor pressure data were reported by von Wartenberg and Schulz¹ and Ruff and Mugdan.¹ We have taken $V = -36.0^{1000}$ or $V_s = -46.7$ at 18° ; whence $Q_f = 37.2$. Mayer's³ data for the reaction, $\text{Cs}^+(\text{g}) + \text{I}^-(\text{g}) = \text{CsI}(\text{g})$, give, for $\text{CsI}(\text{g})$, $Q_f = 38.2$. From the limit of the absorption spectrum, Franck, Kuhn, and Rollefson¹ calculated $D^\circ = -75.0$; whence $Q_f = 30.5$. Sommermeyer,¹ from similar data, gave $D^\circ = -77.8$; whence $Q_f = 33.3$. See also Visser.²

CsI₃ (c), CsI₄ (c). Foote, Bradley, and Fleischer¹ obtained dissociation pressure data on these substances.

Cs₂S (aq.). From the ions, we have obtained, for $\text{Cs}_2\text{S}(\infty)$, $Q_f = 114.08$.

Cs₂S (c). Rengade and Costeaunu¹ measured the heat of solution.

Cs₂SO₄ (aq.). deForcrand⁴⁶ measured the heat of neutralization of $\text{LiOH}(\text{aq.})$ with $\text{H}_2\text{SO}_4(\text{aq.})$. His data, together with the heat of dilution, yield, for $\text{Cs}_2\text{SO}_4(\infty)$, $Q_f = 339.56$. From the ions, we have obtained 339.88. The heat of dilution of $\text{Cs}_2\text{SO}_4(\text{aq.})$ was measured at 25° in the very dilute range by Lange and Streeck.¹ Their values have been converted to 18° and extrapolated to 200 H_2O .

Cs₂SO₄ (c). deForcrand⁴⁶ measured the heat of solution.

CsHSO₄ (aq.). deForcrand⁴⁶ measured the heat of reaction between $\text{CsOH}(110) + \text{H}_2\text{SO}_4(220)$, and between $\text{CsHSO}_4(330) + \text{CsOH}(110)$. His data yield for $\text{CsHSO}_4(330)$, $Q_f = 275.47$ and 275.79 , respectively.

CsHSO₄ (c). deForcrand⁴⁶ measured the heat of solution.

CsI · 4SO₂ (c). Ephraim and Kornblum¹ and deForcrand and Taboury¹ found $D = -10.9$ and -9.9 , respectively.

CsNO₃ (aq.). From the ions, we have computed, for $\text{CsNO}_3(\infty)$, $Q_f = 111.23$. Values for the heat of dilution were given for the range 25 to 400 H_2O by Richards and Rowe,^{2, 3} and we have extrapolated their values to $\infty \text{H}_2\text{O}$.

CsNO₃ (c, II). Haigh¹ measured the heat of solution.

CsNO₃ (c, I). Bridgman^{6a} measured the heat of transition.

Cs₂CO₃ (aq.). deForcrand⁴⁹ measured the heat of neutralization of CsOH (aq.) with CO₂ (aq.). His data yield, for Cs₂CO₃(2000), $Qf = 284.81$; whence (with an estimated heat of dilution to ∞ H₂O), for Cs₂CO₃ (∞), $Qf = 284.85$. From the ions, we have obtained 284.58. deForcrand⁵² measured the heat of dilution from 7.59 to 228 H₂O. We have estimated the values to 2000 and ∞ H₂O.

Cs₂CO₃ (c). deForcrand⁴⁹ measured the heat of solution, and Lebeau¹ the dissociation pressure at various temperatures.

Cs₂CO₃ · 3½ H₂O (c). deForcrand⁵² measured the heat of solution.

CsHCO₃ (aq.). deForcrand⁵³ measured the heat of the reaction of CsOH(110) with CO₂(1800). His data yield, for CsHCO₃(1900), $Qf = 227.16$.

CsHCO₃ (c). deForcrand⁵³ measured the heat of solution. His data give $Qf = 231.0$. Caven and Sand² found, from dissociation pressures, $D = -29.0$; whence $Qf = 241$.

5Cs₂CO₃ · 2CsHCO₃ · nH₂O (c). deForcrand⁵⁴ measured the heats of solution of 5Cs₂CO₃ · 2CsHCO₃ · 10H₂O (c) and 5Cs₂CO₃ · 2CsHCO₃ · 17½H₂O (c).

CsCNS · ½SO₂ (c). Ephraim and Kornblum¹ found $D = -10.1$.

2CsCl · CuCl₂ · nH₂O (c). Bouzat and Chauvenet² measured the heats of solution of the anhydrous salt and the dihydrate.

nCsCl · ThCl₄ · mH₂O (c). Chauvenet² measured the heats of solution of 2CsCl · ThCl₄ (c), 2CsCl · ThCl₄ · 8H₂O (c), and 4CsCl · ThCl₄ (c).

CsAl(SO₄)₂ · nH₂O (c). We have assumed that the heat of solution of CsAl(SO₄)₂ · 12 H₂O (c) is -11.5 , by analogy. The heats of dissociation of the various hydrates have been calculated from the vapor pressure measurements of Krause, Fricke, and Querengasser¹ and Ephraim and Wagner.¹

CsLiClII (c, melt). Beketoff⁸ measured the heats of solution of CsLiClII (c, melt) and of CsI (c) + LiCl (c).

CsNaClII (c, melt). Beketoff⁸ measured the heats of solution of the melt and of NaCl (c) + CsI (c).

CsKClII (c, melt). Beketoff⁸ measured the heats of solution of the melt and of KCl (c) + CsI (c).

ELEMENT 87

M (c). Standard state.

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COMPOUNDS

As indicated on page 15, the formula of the substance, written according to the standard arrangement given on page 16, determines (1) the element under which the compound will be listed and (2) the position the compound will occupy in that section. In the table, all locations are exact; in the text, all main locations are exact and the sublocations are approximately in the proper order. The index for the elements is given below.

ELEMENTS

	TABLE	TEXT		TABLE	TEXT
Actinium	111	337	Germanium	55	254
Aluminum	106	331	Gold	80	296
Antimony	41	224	Hafnium	103	328
Argon	17	171	Helium	17	171
Arsenic	39	223	Holmium	109	334
Barium	126	355	Hydrogen	20	174
Beryllium	112	337	Illinium	110	335
Bismuth	42	228	Indium	61	263
Boron	105	329	Iodine	25	189
Bromine	24	185	Iridium	82	299
Cadmium	67	272	Iron	89	308
Calcium	117	343	Krypton	18	171
Carbon	43	229	Lanthanum	111	337
Cerium	111	336	Lead	58	257
Cesium	168	402	Lithium	131	362
Chlorine	22	179	Lutecium	109	334
Chromium	95	318	Magnesium	113	339
Cobalt	87	305	Manganese	92	314
Columbium	101	326	Masurium	84	302
Copper	73	283	Mercury	69	276
Dysprosium	109	334	Molybdenum	97	321
Erbium	109	334	Neodymium	110	335
Europium	109	335	Neon	17	171
Fluorine	21	178	Nickel	84	302
Gadolinium	109	334	Nitrogen	32	206
Gallium	60	263	Osmium	82	300

	TABLE	TEXT		TABLE	TEXT
Oxygen	19	172	Sodium	137	367
Palladium	83	300	Strontium	122	351
Phosphorus	37	218	Sulfur	27	193
Platinum	81	298	Tantalum	101	326
Polonium	31	206	Tellurium	31	205
Potassium	150	384	Terbium	109	334
Praseodymium	110	335	Thallium	62	264
Protoactinium	101	326	Thorium	104	328
Radium	130	362	Thulium	109	334
Radon	18	172	Tin	56	255
Rhenium	82	300	Titanium	101	326
Rhodium	83	301	Tungsten	98	322
Rubidium	165	400	Uranium	99	323
Ruthenium	84	302	Vanadium	100	325
Samarium	109	335	Xenon	18	172
Scandium	108	333	Ytterbium	109	334
Selenium	30	202	Yttrium	108	334
Silicon	54	252	Zinc	64	266
Silver	77	290	Zirconium	102	327

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